

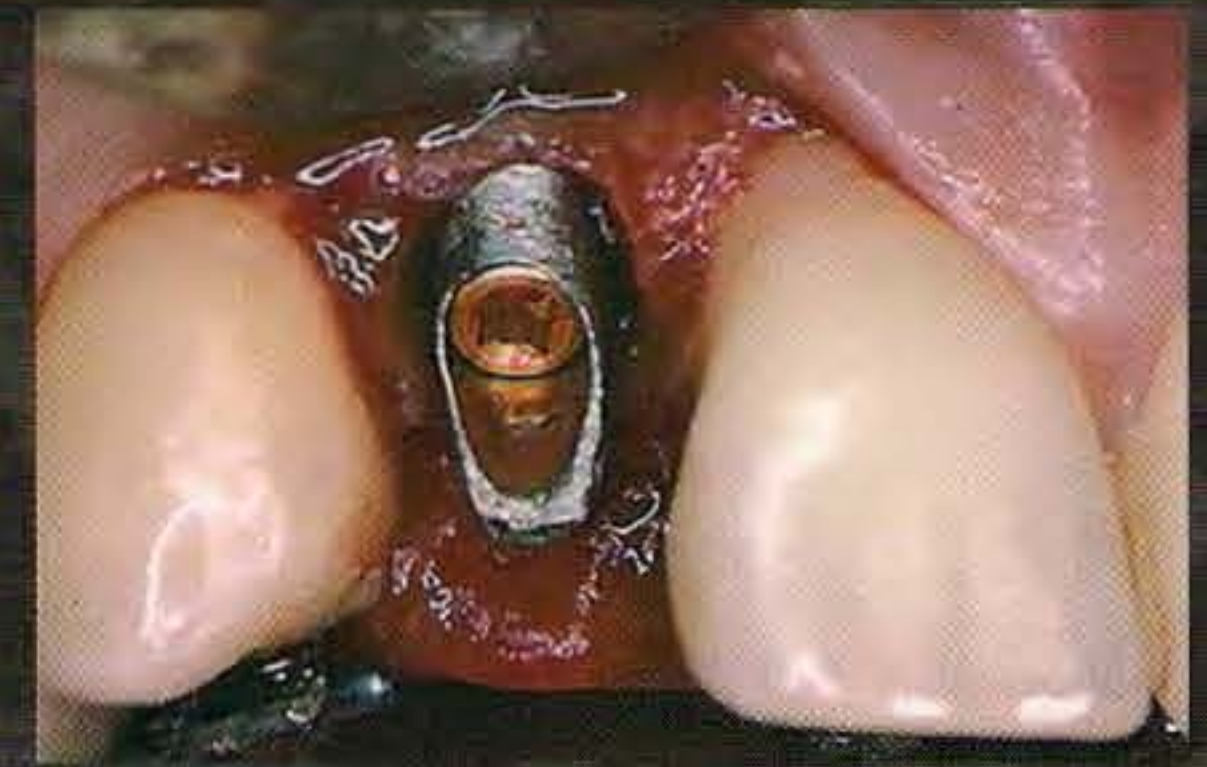
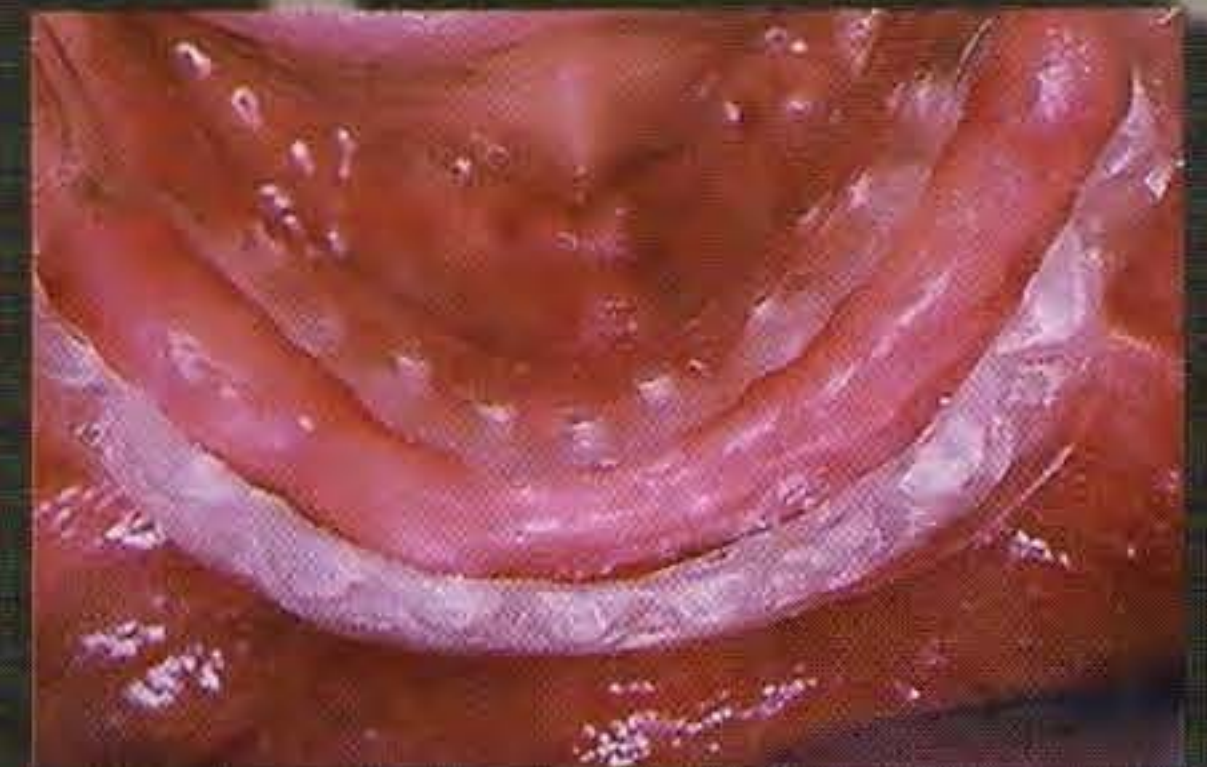
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IMMEDIATE LOADING OF DENTAL IMPLANTS

THEORY AND CLINICAL PRACTICE

Mithridade Davarpanah and Serge Szmukler-Moncler

With contributions by
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Immediate Loading of Dental Implants: Theory and Clinical Practice

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IMMEDIATE LOADING

OF DENTAL IMPLANTS

THEORY AND CLINICAL PRACTICE

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Contents

Acknowledgments vi

Preface vii

Contributors ix

Introduction x

▼ Part I Theory

- 1 Benefits of Immediate Loading 1
- 2 Concepts of Immediate Loading 7
- 3 Differences Between Traditional and Immediate Loading Protocols 17
- 4 Strategies for Optimizing Osseointegration 29
- 5 Three-Dimensional Placement of Implants 45
- 6 Management of Esthetics 71
- 7 Selection of Screw-Retained or Cemented Provisional Prostheses 89
- 8 Failure of Immediately Loaded Implants 95

▼ Part II Clinical Practice

- 9 Key Concepts of Treatment Planning 99
- 10 Treatment of the Edentulous Mandible 107
- 11 Treatment of the Edentulous Anterior Maxilla 161
- 12 Treatment of the Edentulous Maxilla 223
- 13 Treatment of the Edentulous Anterior Mandible 277
- 14 Treatment of the Edentulous Posterior Mandible and Maxilla 303
- 15 NanoTite: A New Type of Bioactive Surface 343

Index 353

Acknowledgments

Though acknowledgments are found in the first pages of a book, they are the last pages to be written—it could not happen any other way. Failure to include them would be not only an affront to tradition but also a denial of reality because of the many people, in addition to the primary authors, who have participated in the preparation of this work. All of their diverse and varied contributions have been important.

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It is standard practice for authors to thank their spouses, their significant others, and their families. This is by no means an insincere exercise, because considerable time is required for research and writing, and authors consequently often neglect those closest to them; it is essential, therefore, to recognize and honor the tolerance of these loved ones. We thank Leila for her patience and her gift of that priceless commodity, time; Carolynne for having lavished indispensable consolation at all hours of the day and night; the nonmythical Trojan for having organized the flowing scribbles that emptied so many ink wells; Marian for chauffeuring services devotedly performed even in the darkest hours of the night; and Chaguit for tolerating the often interminable waiting.

If our children, Keyvan, Kourosh, Anoushka, Meier-Alexander, Alex, and Mirona, suffered from our frequent lack of availability, they also rejoiced in the newfound freedom this afforded them.

Thanks must also be paid to our fathers, Cyrus and Natanael, and our mothers, Huguette and Bella. Whether they are with us in body or only in memory, they have played significant roles in this endeavor by being the original progenitors of the spirit that informs it. It is hoped that Maruan and Antoinette, who have had to accept geographic distance between themselves and their child, discern in the pages of this book the high esteem in which they are held.

Throughout the long hours of this book's creation, one of us sought out the restorative insight found at Pierrette's roundtables, both from Pupuce's inspired teaching and the assistance of Ruth and Chams. Peter from DOT in Rostock has helped significantly—without knowing it—to feed our fountain pen with ink of premium quality.

We would be remiss in not acknowledging the editorial guidance Dr Christian Knellesen has generously and unfailingly provided to us. Sometimes, he even agreed to put the cart before the horse and, surprisingly, this unusual harnessing seemed to make the team advance more speedily than ever. Sophie Gresse, like a guardian angel, deftly smoothed out all the rough edges and ensured that the cogs of our enterprise were always well oiled and turning effortlessly.

Who would have thought 11 years ago that an authoritative text, or even a simple book, could be written about immediate loading of dental implants? At that time, the struggle between the Swedish school, which advocated a two-stage surgical procedure with lengthy healing periods, and the Swiss school, which favored a one-stage procedure for implant placement, was still being hotly waged.

However, since 1997, developments have come at a dizzying pace. In that year, the first paper ever presented on immediately loaded implants won the first research prize at the meeting of the European Association for Osseointegration,¹ thanks in part to the efforts of one of the authors (SSM). In November of that same year, thanks also to the efforts of the same author (SSM), the first world convention exclusively focused on immediate loading took place. (Prof G. Favero and Prof A. Piattelli were the organizers.) Over the course of a day and a half in Venice, 300 participants learned what was occurring in European and North American universities under the auspices of renowned researchers and clinicians.

In 1998, the first review of the literature on immediate loading was published.² Then in 1999, Brånemark,³ the father of the Swedish school, overturned his recommendations and published his first article on immediately loaded mandibular implants.

Since then, immediate loading has become one of the hottest as well as the most relevant topics in implant dentistry. The number of publications on this subject has increased exponentially. Every manufacturer of implants and every university has rushed to contribute to the clinical and experimental knowledge.

Practitioners with 25 years of experience are seeing a return to old ideas. In the 1970s and 1980s, immediate loading was used routinely in daily practice. Soon after, however, practitioners had to abandon the technique for fear of being discredited. Now these pioneers claim that there is nothing new under the sun. They are wrong in this assertion, however, because the immediate-loading protocols that were employed in the pre-Brånemark era have nothing in common with the technique that is practiced today.

For young practitioners immediate loading has never been a taboo subject, and they have no inkling of the historic conflict between the feuding factions. Immediate loading is just one of their natural points of reference.

Practitioners who are in the middle of these two groups and who should constitute, at least in the beginning, the bulk of the readership of this book, have the hardest road to follow. They were inculcated with the rigid principles of osseointegration, as promulgated by Brånemark, almost as though they were religious dogma. For them, switching from the lengthy healing protocols to immediate loading has demanded a veritable intellectual revolution, a cognitive rupture, a paradigm shift. They have had to burn their old idols, who only yesterday were adored gurus, and toss some of the most basic principles of their professional education into the rubbish heap after having condemned them as obsolete.

Those who have dared to take the crucial first step into this new world have been able to fully appreciate the difference between the daily practice of implant dentistry with and without immediate loading. To make this leap, these practitioners have had to integrate into their intellectual framework new ideas, a large body of fresh information, and a new approach to implant treatment. They have had to reorganize not only their relationships with collaborating surgeons, restorative dentists, and laboratory technicians but, indeed, their whole mode of operation. They have also had to recognize the intricacies of the new procedure, the different possibilities it offers and, above all, its limitations.

The authors of this book traversed this difficult path when its course was poorly charted. We groped our way along new trails, making tentative decisions, sometimes limping, sometimes stumbling, and finally succeeded in establishing a certain route. We have gathered the results of this protracted effort and present them here to the largest possible professional audience to provide access to an

advantageous and effective technique. As widespread acceptance of immediate loading becomes more and more inevitable, the patient becomes the principal beneficiary.

The Biomet 3i implant system and its specific components have been used throughout the book. Nevertheless, we have been careful to describe principles rather than specific components. No matter what implant system is employed, all readers of this book will derive useful information from it.

Practitioners who have experienced immediate loading are like travelers who have enjoyed a high-speed train. Once they have experienced it and learned to appreciate its advantages and efficiency, they never want to return to the old, slow ways of reaching their destinations.

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Introduction

In the last three decades, implant dentistry has emerged as a fully accepted discipline in dentistry. During this period of development, its concepts and treatment modalities have undergone tremendous changes. At first, only protocols involving two-stage surgery were recognized as providing reproducible and reliable results.¹ Later, a single-stage surgical procedure became acceptable.²⁻⁶ Later still, the waiting periods for bone healing were shortened; instead of 3 to 8 months, no more than 6 to 8 weeks was deemed necessary.⁷⁻¹⁰

However, the rediscovery of the immediate-loading protocols, which for decades had been considered untenable, must be viewed as a veritable revolution.¹¹ We cannot completely dismiss the possibility that this renewed interest is merely a passing fancy, but the large number of publications and studies devoted to the technique are convincing evidence of the widespread acceptance of this procedure. An analysis of the literature of recent years shows that interest in immediate loading is growing steadily and that more attention is being directed at the clinical implications of immediate-loading protocols than at early loading (Fig 1).

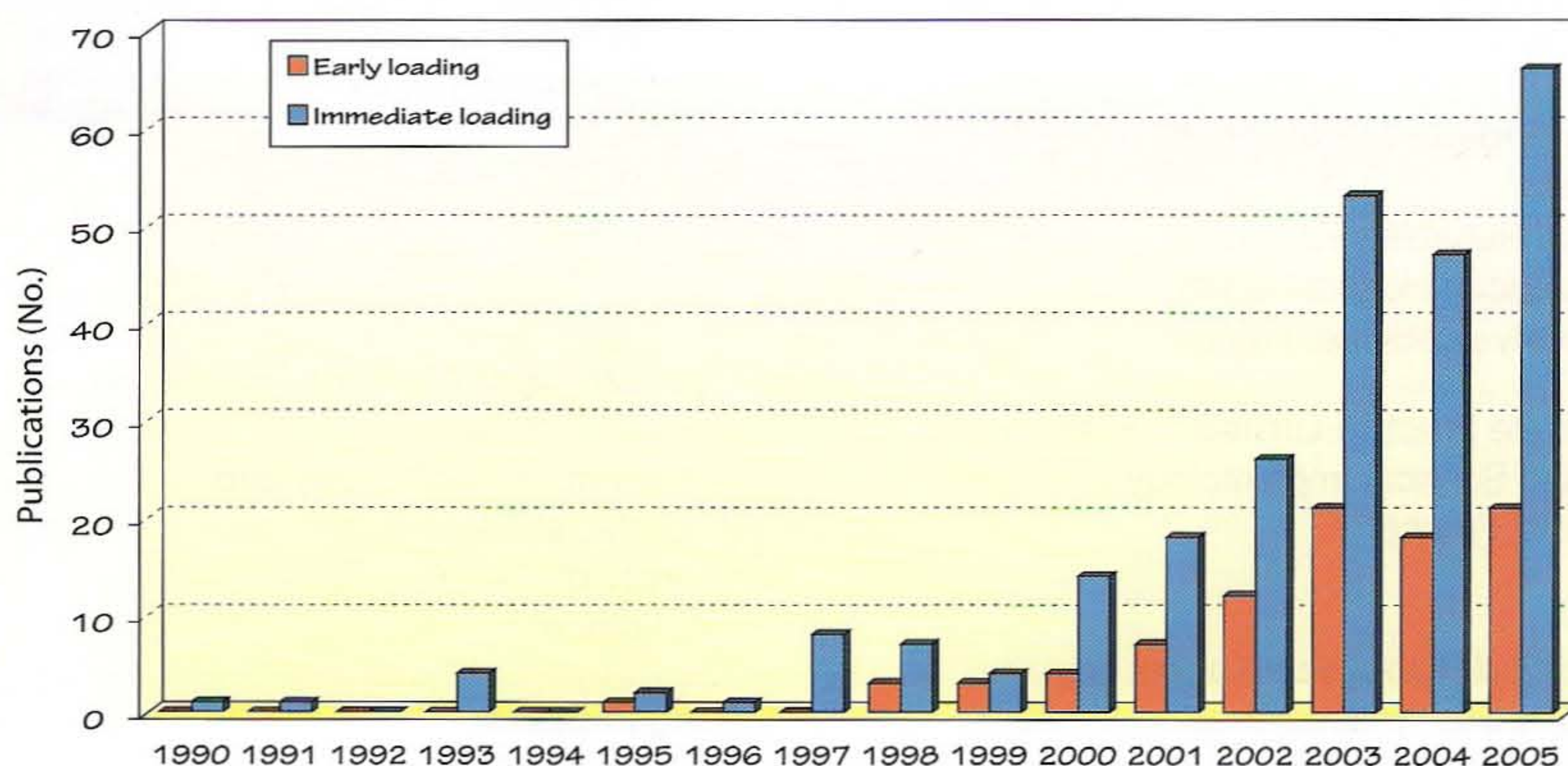


Fig 1 Relative increase in the number of publications concerning immediate and early loading, year by year. The curves representing the two protocols are quite different. The number of publications about immediate loading is increasing rapidly.

Immediate-loading protocols have two distinct prerequisites. The first is biologic: the acquisition of osseointegration, despite the forces exerted during the healing phase, in conjunction with maintenance of a satisfactory esthetic response of the surrounding soft tissues. The second challenge is logistic: the prosthetic phase follows the surgical phase as swiftly as possible.

In effect, apart from the biologic aspect, the most distinctive difference between the protocols for immediate loading and those for early or conventional loading is chronologic, that is, the shortened interval between the surgical and the prosthetic phases. It is this sequential proximity that practitioners must learn to manage in terms of both the logistics of their own practice and coordination with all of the members of the multidisciplinary team. The complicated part is being able to already have thought about everything and to continue to think about everything at the same time.

Before the specific principles of the immediate-loading protocol are discussed, it is important to define this concept and agree on terminology. The following must be determined:

- The acceptable interval between implant placement and prosthetic loading
- The type of forces exerted on the implant and the prosthesis

Opinions vary about the maximal acceptable interval between implant placement and loading. Some researchers use the term *immediate loading* only when the provisional prosthesis is placed during the same session in which surgery is performed.¹² Others believe that, to qualify as an immediately loaded implant, the definitive prosthesis must be placed on the same day.¹³ Still others accept a delay in loading of 48 hours¹⁴ to 72 hours.¹⁵ Regardless, these conceptualizations remain empirical because none of them is based on physiology and biologic reactions at the bone-implant interface.

The delay most often observed for orderly placement of a prosthesis directly after the surgical procedure ranges between several hours and 5 days. It would be tempting to use this practical framework in the definition of immediate loading. However, many studies have documented results of treatment that followed an arbitrarily determined delay of 48 to 72 hours. That is why we have used this interval throughout this volume, without in any way judging the validity of its parameters. For the time being, practitioners should respect this 48- to 72-hour interval until a more precisely documented paradigm has been established.

The biomechanical definition of *immediate loading* is also debated:

- For some researchers, the concept of immediate loading is satisfied as soon as the coronal portion of the prosthesis is inserted, even if it is kept out of occlusion.¹⁵
- For others, the term *immediate loading* can be applied only if the prosthesis is subjected to occlusal forces as soon as it is inserted.¹²

The difference is significant because the forces exerted on a prosthesis in full occlusion are expected to be greater than those on one that is out of occlusion.

Those who include all prostheses, in or out of occlusion, in their immediate-loading protocols also differ in their choice of descriptors. The two situations are described variously with these labels:

- *Immediate occlusal loading vs immediate functional loading*¹⁵
- *Immediate functional loading vs immediate nonfunctional loading*¹⁶
- *Immediate loading vs immediate provisionalization*¹⁷⁻¹⁹

Whatever they are called, these circumstances are the two themes covered by this book. In both cases, the practitioner embarks on the prosthetic treatment immediately after the surgery has been completed. This means that within 72 hours, a prosthesis will be exerting considerable pressure on the implants supporting it, in an interaction that is described as *immediate loading*. To simplify matters, throughout this book we refer to the two aspects as *immediate loading in occlusion* and *immediate loading out of occlusion*.

Clinicians will find management of the logistics in the two scenarios to be about the same. Only the strategies required for minimizing stresses exerted at the bone-implant interface will differ. Whenever possible, it is best to keep the restoration out of occlusion, but when this is impossible, as in treatment of an edentulous mandible or maxilla, occlusal forces should be minimized by distributing them over a greater number of implants.

When confronted with a new technique, the members of any given professional community respond to it in one of three ways: with enthusiasm, skepticism, or, in most cases, relative indifference. The concept of immediate loading is no exception; it has its enthusiasts, its detractors, and a large body of hesitators who take a wait-and-see approach. The last group needs time to accept the innovative procedure and to incorporate it into their daily practice.

We have taken an active role in establishing the foundation for the immediate-loading protocol and are eager to tell others what we have learned so that the greatest possible number of practitioners and patients will be able to benefit from this new technique. This book was designed to elucidate the basic principles of immediate loading, from patient selection to surgical procedures to the final adjustment of the completed restoration. In addition, the chapters describe solutions to the various challenges that may be encountered along the way. This comprehensive volume provides readers with concrete guidelines for a proven technique that simplifies implant procedures and provides clear benefits to patients.

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Chapter I

BENEFITS OF IMMEDIATE LOADING

*Mithridade Davarpanah
Serge Szmukler-Moncler
Paul M. Khoury
Boris Jakubowicz-Kohen
Mihaela Caraman*

▼ Benefits for the Patient

The principles of conventional implant dentistry dictate that implants be subjected to as little stress as possible during the period of bone healing.¹ This protocol requires a 2- to 6-month healing period before implants can be loaded (Fig 1-1). Accordingly, to nurture the best bone healing, no appliances should be inserted in the treated area.

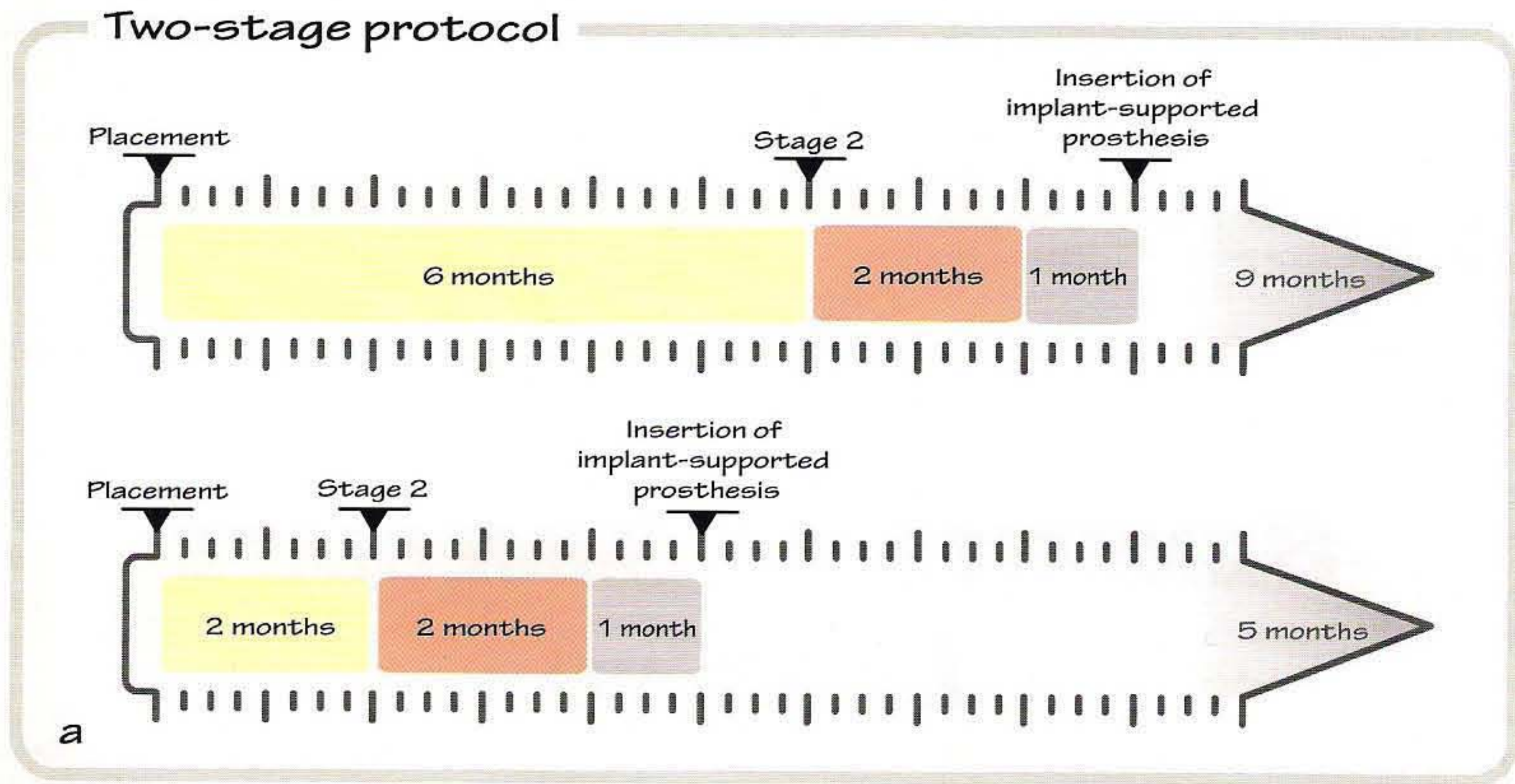
When only posterior teeth are involved, patients do not complain about this lengthy approach. However, they are unwilling to endure long delays when they are missing all the teeth in either arch or when they have lost teeth in the esthetic zone. Dental clinicians should respond sympathetically and effectively to the social and psychologic needs of their patients by providing provisional replacements for missing teeth during the bone-healing period.

For the completely edentulous arch, a complete denture, generously relieved over the healing caps, is the most common provisional solution (Figs 1-2a and 1-2b). The relieved areas are intended to prevent the provisional denture from exerting pressure on the underlying implants. The relieved denture will be less retentive and much more uncomfortable, however.

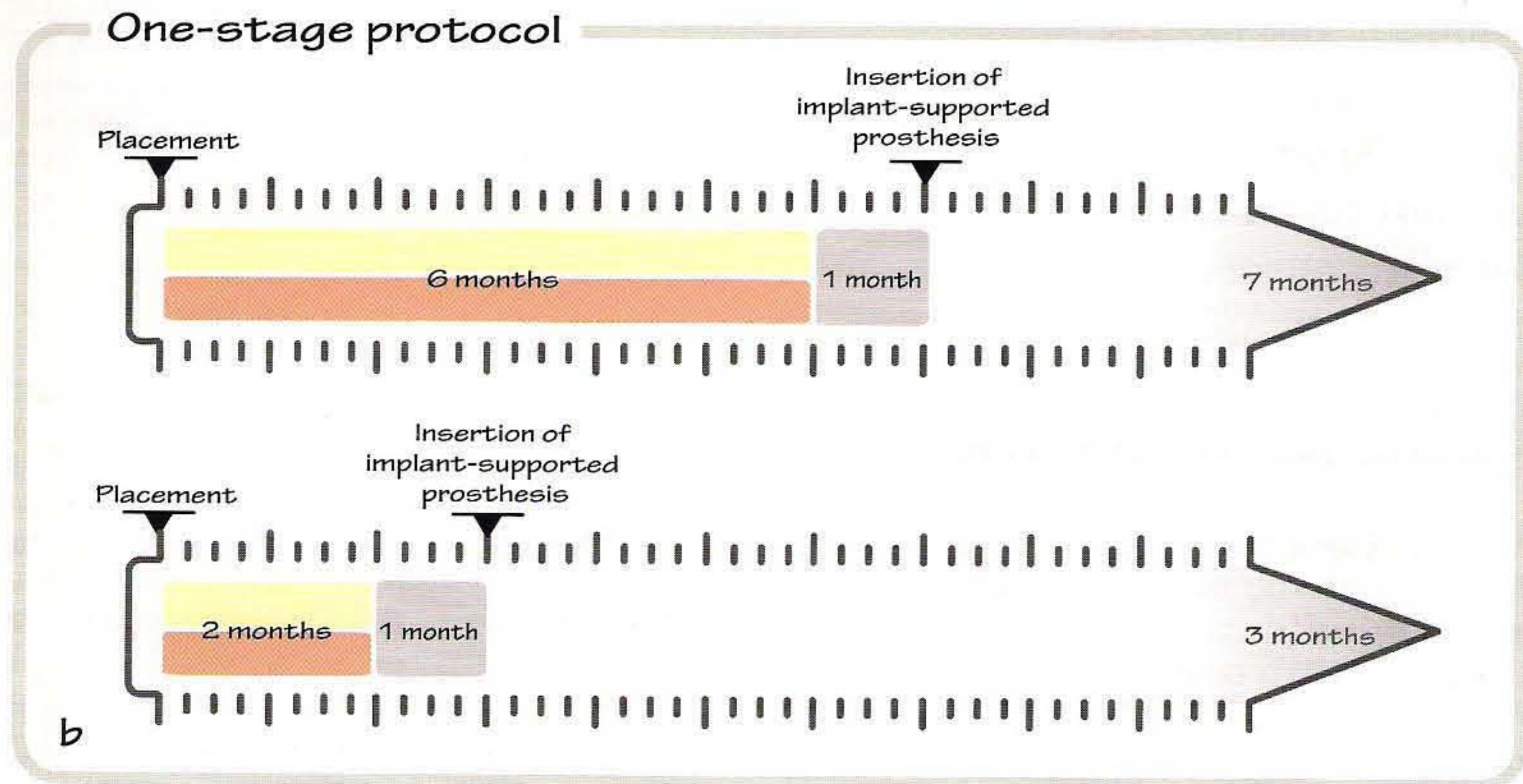
If only a single tooth is absent or just a few teeth are missing, they can be replaced with a removable prosthesis stabilized by clasps or with crowns or fixed partial dentures bonded to the adjacent teeth (Figs 1-2c and 1-2d). These provisional restorations often have serious esthetic and functional shortcomings. Their cervical portions have to be trimmed well above the mucosa to prevent them from interfering with the healing of nearby hard and soft tissues. In addition, because of their bulkiness, bonded replacements may interfere with the patient's perception of physical integrity.

Immediate loading represents a great improvement over these flawed measures in responding immediately to the esthetic and functional needs of patients. Instead of having to wait 4 to 10 months, as required by traditional protocols, patients can receive their implant-supported prostheses within 1 to 72 hours after surgery. This prompt and effective way to manage the loss of

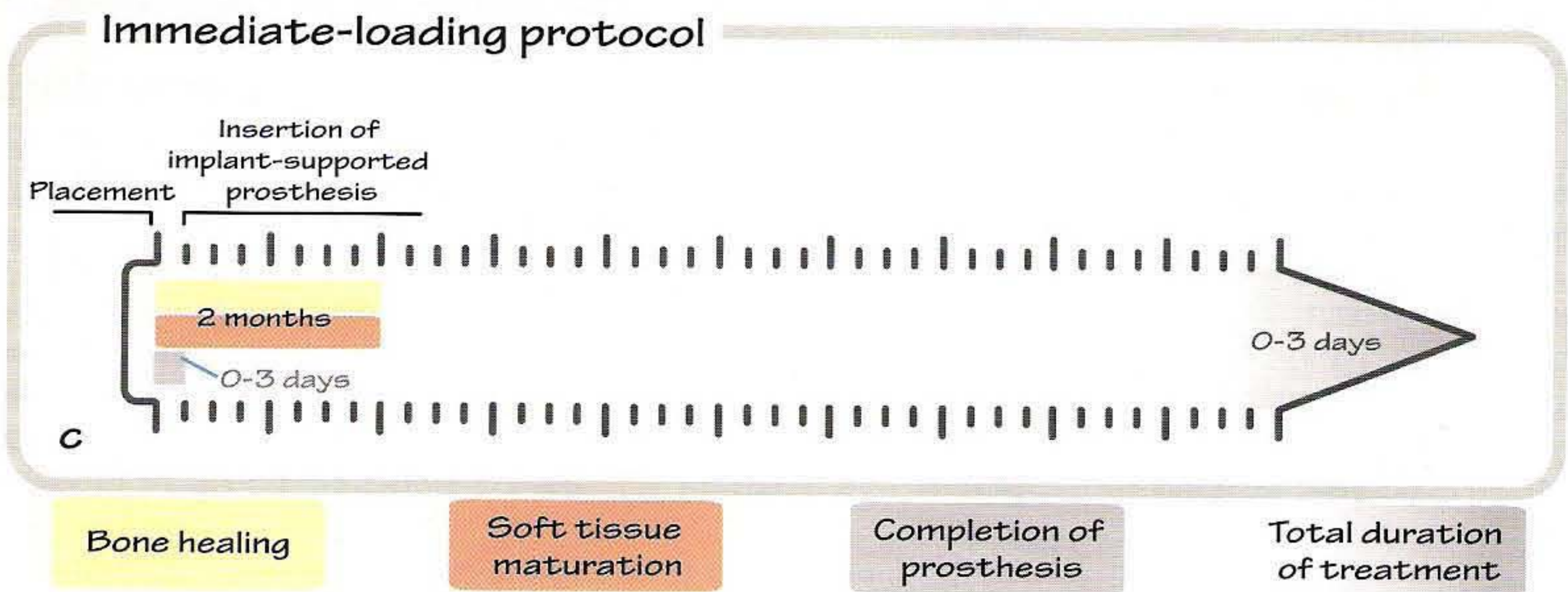
Two-stage protocol



One-stage protocol



Immediate-loading protocol



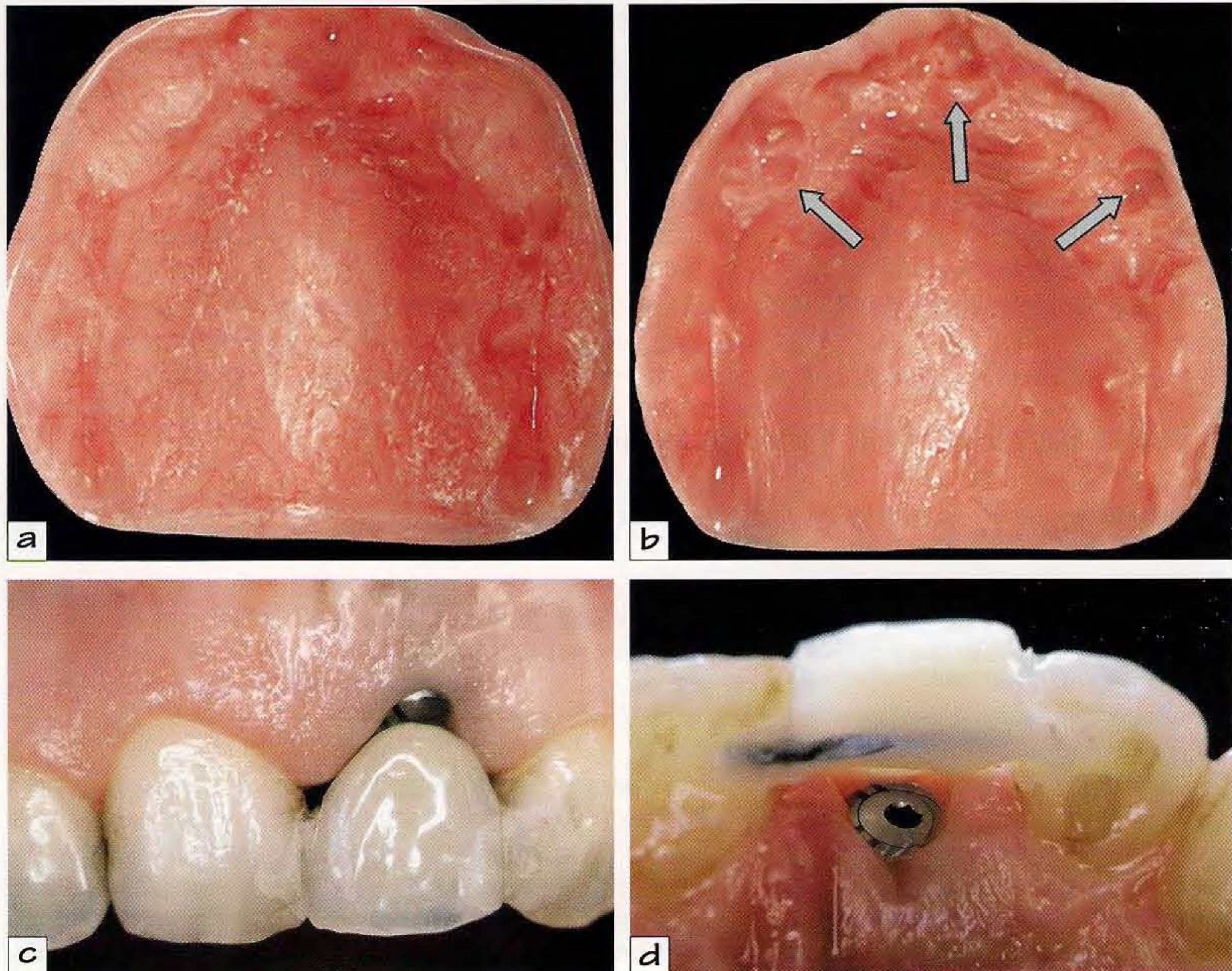
Bone healing

Soft tissue maturation

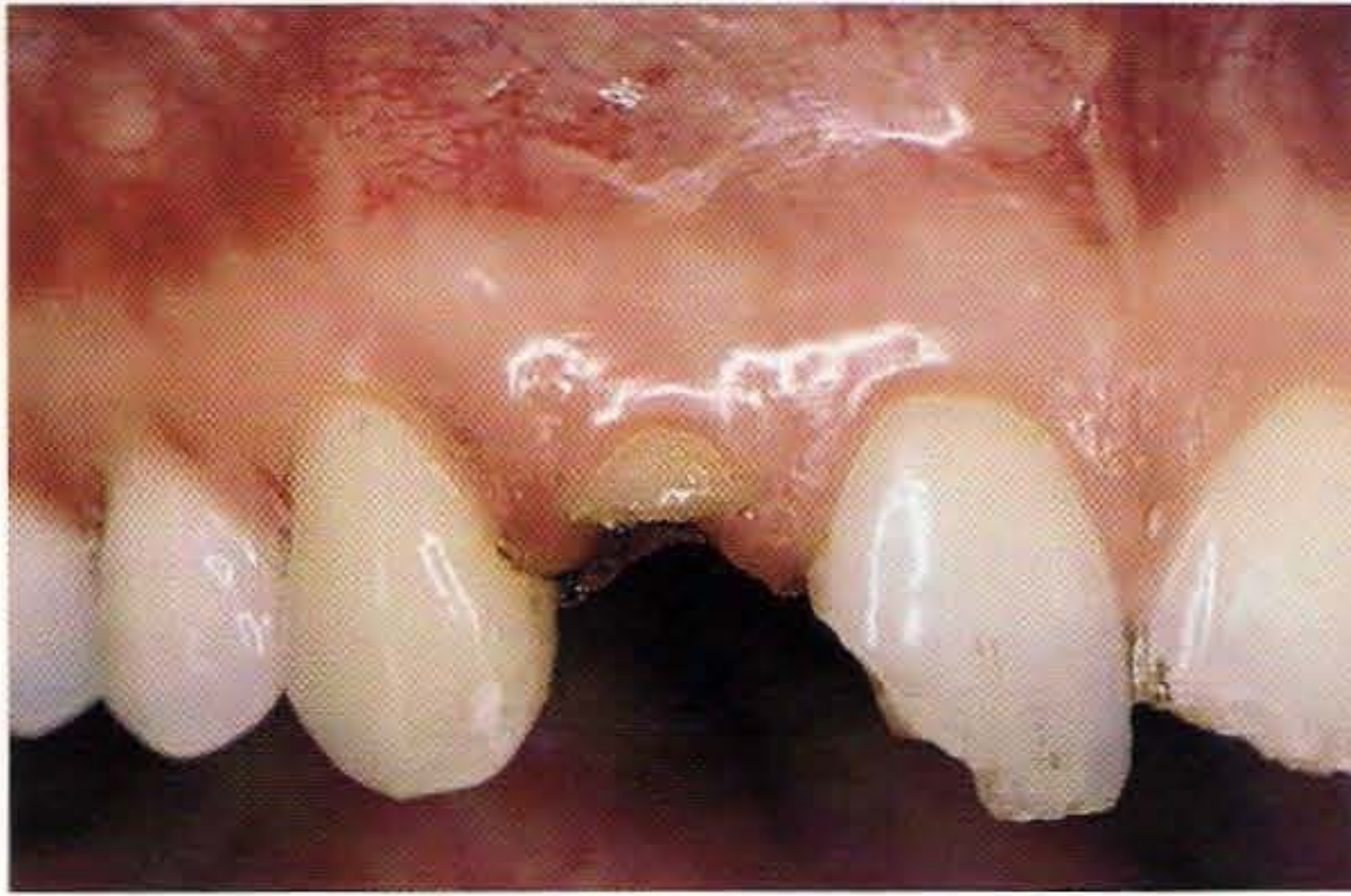
Completion of prosthesis

Total duration of treatment

▲ **Fig 1-1** Treatment alternatives for a partially edentulous anterior maxilla. (a) Two-stage protocol, with standard- and early-loading periods. Depending on the time allotted for healing, 5 to 9 months could pass between implant placement and delivery of a fixed implant-supported prosthesis. (b) One-stage transgingival protocol with standard- and early-loading periods. Depending on the time allotted for healing, 3 to 7 months could pass between implant placement and delivery of a fixed implant-supported prosthesis. (c) Immediate-loading protocol. The fixed implant-supported prosthesis can be placed a few hours or, at most, 3 days after insertion of the implants. Bone healing and soft tissue maturation take place while implants are under function. Yellow represents bone healing, red indicates soft tissue maturation, gray depicts the time needed to prepare the implant-supported prosthesis, and the gradation represents the total treatment time.



▲ **Fig 1-2** Provisional prosthetic measures during the healing period. (a and b) For the edentulous arch. (a) The complete denture the patient had been wearing was retentive. (b) After implant placement, the denture is appropriately relieved (arrows) so that it will not interfere with soft tissue healing or exert any pressure on the implants. However, this makes the provisional denture less retentive and more uncomfortable. As healing progresses, the denture is relined with soft acrylic resin. (c and d) For the partially edentulous arch. (c) The implant has not been loaded and a provisional fixed partial denture has been bonded to the adjacent teeth. To protect the implant during the healing period, the provisional crown has been generously trimmed at the gingiva, compromising esthetics. (d) Lingual view of the bonded prosthesis.



◀ **Fig 1-3** Trauma leading to extraction of the maxillary right lateral incisor of a young adult. Suitable implant rehabilitation will comprise an immediate-loading protocol.

teeth increases patients' acceptance of implant treatment.^{2,3} It has completely transformed the way patients perceive implant therapy: They no longer perceive it as a long and protracted treatment but as a simple, rapid, and effective therapy. Figure 1-1 shows the sequence and timing of steps for the various protocols in use today for implant insertion and placement of implant-supported restorations. The advantages of immediate loading are evident.

Sometimes patients are emotionally unprepared for sudden tooth loss, such as when trauma necessitates tooth extraction (Fig 1-3) or when a partial denture is failing because of hopeless teeth. In these cases, immediate loading can provide great psychologic benefits.

▼ **Benefits for the Practitioner**

For the implant team, provisional prostheses that are not implant supported are unsatisfactory for a number of reasons:

- Patients often find provisional prostheses uncomfortable, ill fitting, and unstable.
- Patients may find it difficult to accept the relatively poor esthetic and functional quality of the provisional device.
- Patients have to make frequent office visits for adjustments.

Treatment of an edentulous arch requires numerous, lengthy appointments to relieve sore spots or reline the entire provisional appliance. These activities place great demands on the practitioner's time.

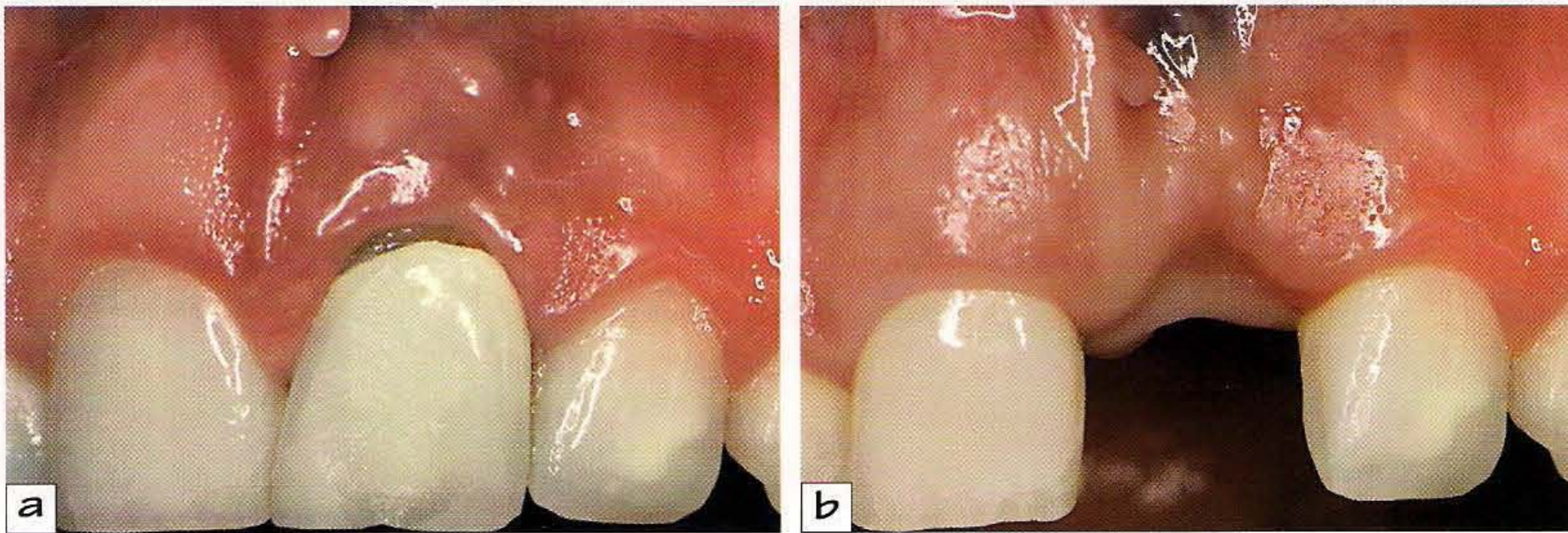
For partially edentulous patients who do not want or cannot tolerate a removable partial denture, dentists can make provisional bonded prostheses. However, they have to be removed and then rebonded at every appointment during crown preparation and prosthesis-fitting sessions. Again, treatment time increases.

Immediate loading requires fewer appointments. This attractive alternative provides time- and cost-saving advantages that ease practice management (see chapter 3).

Furthermore, practitioners will gain professional satisfaction from knowing that they have proposed a treatment plan that can be carried out efficiently and expeditiously in accordance with the most advanced techniques available.

▼ **Benefits of Immediate Treatment**

The benefit of immediate loading depends on whether the site is healed or is a fresh extraction socket. Immediate placement of an implant into an extraction site can prevent the bone resorption that normally occurs (Fig 1-4) and maintain the osseous volume of the site.^{4,5} Immediate loading



▲ **Fig I-4** Bone loss following tooth extraction. (a) Clinical view before tooth extraction. (b) Clinical view 3 months after extraction. The buccal bone exhibits noticeable resorption. If an implant had been placed immediately after the extraction, the osseous volume and the shape of the soft tissues could have been preserved.

will preserve the gingival margins and the papillae of the tooth that has just been removed.⁶ In healed sites, bone loss will have already occurred, the osseous crest will be flat, and the papillae will have disappeared. Simultaneous healing of hard and soft tissues will appreciably shorten the treatment time and provide a rapid picture of the esthetic result.

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Chapter 2

CONCEPTS OF IMMEDIATE LOADING

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▼ Evolution of Implant Dentistry

Before the details of the immediate loading technique are discussed, it is necessary to review the reasons why the procedure was anathema to Brånemark and his followers.¹ It is also crucial to understand why these same scientists have now embraced the concept some 30 years later.²

The history of implant dentistry can be divided into three distinct parts: (1) the pre-Brånemark era, (2) the Brånemark era, and (3) the post-Brånemark era. In each era, different concepts prevailed; these concepts are summarized in Box 2-1.

During the pre-Brånemark days, implantology moved in fits and starts. Implant placement techniques had not yet been codified into a precise series of steps with instruments adapted to each. In that first period, the prevailing view was that nature had to be imitated as closely as possible. Implant dentists strove to create a fibrous tissue envelope around the implant that would simulate the periodontal ligament. It was believed that this tissue would act as a shock absorber to

Box 2-1 Evolution of concepts in implant dentistry

Pre-Brånemark era

- The goal is to simulate periodontal tissues to obtain fibrointegration in an effort to minimize stresses at the bone-implant interface.

Brånemark era

- The goal is to obtain osseointegration without fibrous interposition.
- Satisfactory osseointegration can only be achieved after a suitable healing period.

Post-Brånemark era

- Immediate loading does not, in itself, interfere with the process of osseointegration.
- To guarantee osseointegration, the level of micromovement should be kept below a certain tolerance threshold.

extend the life of the implant by attenuating the forces exerted at the bone-implant interface.³ It is now known that this concept was erroneous and that the presence of fibrous tissue around an implant is a guarantee of failure.¹ The periodontal ligament is a highly differentiated tissue in which fibers are arranged perpendicularly to the implant axis; the tissue is richly innervated and vascularized. In contrast, the fibers of the encapsulating tissue around an implant are undifferentiated and parallel to the root; they are poorly innervated and vascularized.⁴ During the pre-Brånemark era, no clinical studies were undertaken, and the success rate of 50% or less was freely acknowledged.¹

The Brånemark era began when the Swedish researcher and his team proposed a new paradigm that superseded the one that was then accepted by most clinicians throughout the world. This new approach postulated that growth of fibrous tissue between the implant and surrounding bone was deleterious and magnified the harmful effect of stresses at the bone-implant interface. The Brånemark group asserted that if the implant came into direct contact with surrounding bone, without an intervening barrier, its longevity would be prolonged.⁵ In vivo animal experiments, supported by long-term clinical trials, confirmed this concept, which became known as *osseointegration*.⁶ In 1977, the Brånemark team¹ published a study that systematically reviewed the fate of every implant they had placed. They were able to report a success rate markedly higher than those cited in previous studies by other researchers. After an international convention held in Toronto in 1982, universities throughout the world began to integrate implant dentistry into their curricula. In the next two decades, a host of investigators published a great number of clinical studies of the new technique that reported success rates that ranged from 95% to 100%.

The post-Brånemark era began when the scientific community studying implants began to realize that immediate loading did not, in itself, lead to the unwanted fibrous tissue encapsulation and subsequent failure of the implant. Researchers realized that excessive micromovement at the bone-implant interface was responsible for failures of osseointegration.⁷⁻⁹ In addition, they found that a threshold for micromovement could be established.¹⁰⁻¹² If micromovement could be kept below this limit, immediate loading would have no damaging effects.

▼ Evolution of Clinical Implant Protocols

Specific clinical protocols have been established in each implant era (Box 2-2). In the pre-Brånemark era, implants were loaded immediately after placement, with the aim of stimulating bone apposition at the bone-implant interface.³ Blade implants made of titanium or titanium alloy were the most frequently used, but their primary stability was unpredictable.^{8,9} At that time, the discipline of implant dentistry was not accepted in dental universities.

The protocols of the Brånemark era were characterized by a long delay in loading and protective covering of the implants during an obligatory 3- to 8-month submerged healing period.^{1,6} The protocols for this period were thus clearly differentiated from those of the previous era. Numerous studies claimed high success rates for the new technique. Implant dentistry became legitimized, and the credentials of this protocol were firmly established when it was accepted and taught at universities around the world.

The protocols of the post-Brånemark era stipulate immediate loading of implants, usually within 48 to 72 hours after placement. To be suitable for immediate loading, implants have to achieve satisfactory primary stability.⁹ In the effort to increase resistance to micromovement, clinicians and investigators have developed specific operative and prosthetic protocols to ensure implant stability.¹³⁻¹⁶

Box 2-2 Evolution of implant protocols

Pre-Brånemark era

- Loading is immediate in an effort to stimulate a bone response to implantation.

Brånemark era

- Loading is delayed through a two-stage surgical procedure. The implant is covered with gingiva during the mandatory healing period.

Post-Brånemark era

- Loading is immediate but the extent of micromovement is limited.

▼ Emergence of Immediate Loading

During the Brånemark era, the procedural protocols for implant placement were strict and clearly delineated.⁶ The goal was to ensure that practitioners produced predictable results. Strict adherence to protocol was recommended as a means to convince the faculty at dental schools to accept implants as a legitimate component of dentistry and to conduct research that established implants more fully in the broader field of dentistry. These requirements are listed in Table 2-1; the supporting scientific arguments for each practice¹⁷⁻²¹ are shown in Table 2-2. These arguments, which formed the basis for the delayed-loading protocol, were put into question after many animal and clinical studies failed to establish their validity. All but two of these requirements are now considered outdated.²²

The great majority of clinicians followed the recommendations of the Swedish school; in doing so, they obtained satisfactorily high success rates. This encouraged a number of research teams to simplify the protocols to make implants even more widely accessible. They began to question some of the Swedish dictates, especially the need for a submerged healing period and two-stage surgery. By the mid-1970s, Schroeder et al²³ were able to show that submerged healing did not, in fact, constitute an essential condition for implant osseointegration. The success rates they obtained for implants placed in a one-stage procedure were as high as those obtained for implants placed in a two-stage procedure.²⁴⁻²⁷

As time passed, the other requirements of the original Brånemark protocol were reevaluated and determined to be the equivalent of protective armor for a pioneering and relatively untested concept rather than essential and indispensable conditions for obtaining osseointegration. Of all

TABLE 2-1 Requirements designed to promote osseointegration during the Brånemark era

Protocol	Status
Use of biocompatible material (eg, titanium)	Still in use
Inclusion of a submerged healing period in a two-stage surgical protocol	Obsolete
Delay of at least 3 to 8 months before implant loading	Obsolete
Use of low rotary speed to ensure atraumatic bone drilling	Still in use
Use of a buccal incision, away from the crest	Obsolete
Surgery under hospital-type sterile conditions	Obsolete
Use of only titanium instruments and materials (pliers and plates)	Obsolete
Avoidance of radiographs during the healing period	Obsolete
Use of acrylic resin for prosthetics	Obsolete

TABLE 2-2 Scientific arguments in favor of delayed loading

Argument	References
Premature loading can lead to implant fibrous encapsulation instead of direct bone apposition.	17, 18
Necrotic bone at the implant osteotomy site cannot resist loading forces, so it must be replaced by new bone before loading.	17–19
Bone that has newly formed around the implant is not capable of resisting loading forces until it has completed the maturation process.	17–19
Rapid remodeling of the peri-implant necrotic bone compromises the mechanical resistance of the bone-implant interface.	20
Crestal bone integrity can be damaged by weakening bone remodeling at the end of the bone healing period.	21

the surgical paradigms of the Brånemark era, the only one still followed is atraumatic drilling to avoid elevation of the temperature of surrounding bone.²²

Similarly, clinicians and researchers have had to revise their understanding of the physiology of bone healing. During the Brånemark era, it was accepted that drilling of bone would inevitably lead to necrosis of the peri-implant bone^{6,17,18,28} (Fig 2-1). At that time, a waiting period was considered indispensable to allow new bone to replace the necrotized tissue and ensure that implants could support the occlusal load placed on them. Today, however, enough evidence is available to demonstrate that osseous necrosis does not necessarily happen every time^{29,30} (Fig 2-2). Accordingly, a waiting period before bone is subjected to occlusal loading is not mandatory.^{31,32}

Therefore, almost all of the paradigms of the Brånemark era have been revised so that the dental scientific community has been able to reassess immediate loading. In this new framework, a number of reports have shown that the success rate for immediately loaded implants is as high as that obtained for implants with a delayed-loading period.^{22,33}

▼ Principles of Immediate Loading

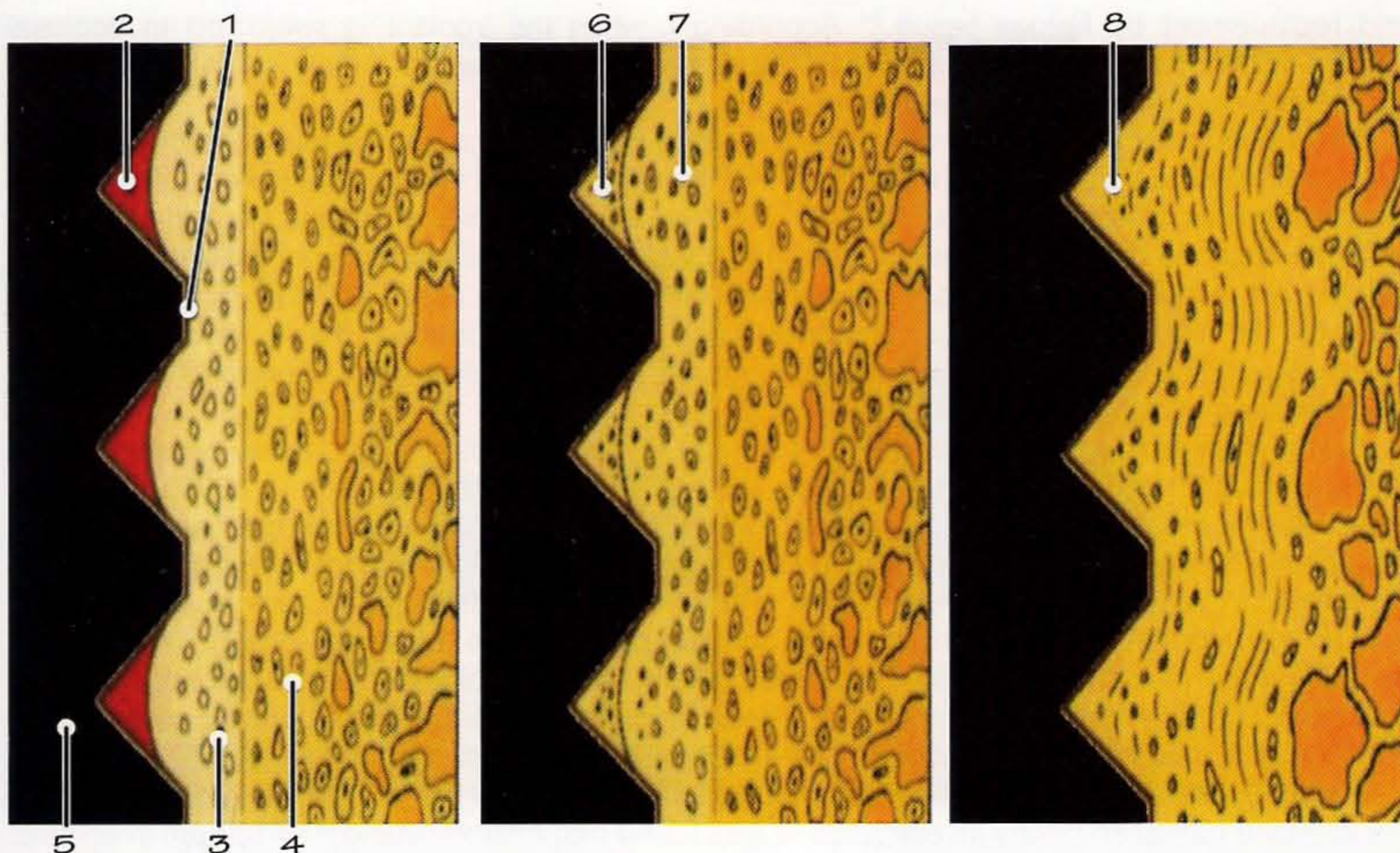
During the time that most implantologists believed that bone healing required the absolute absence of stress, some researchers observed that:

- The complete absence of stress at the bone-implant interface was preventing active osteogenesis.^{31,32}
- Excessive micromovement at the bone-implant interface, on the other hand, did inhibit osteogenesis.^{10,11,34}

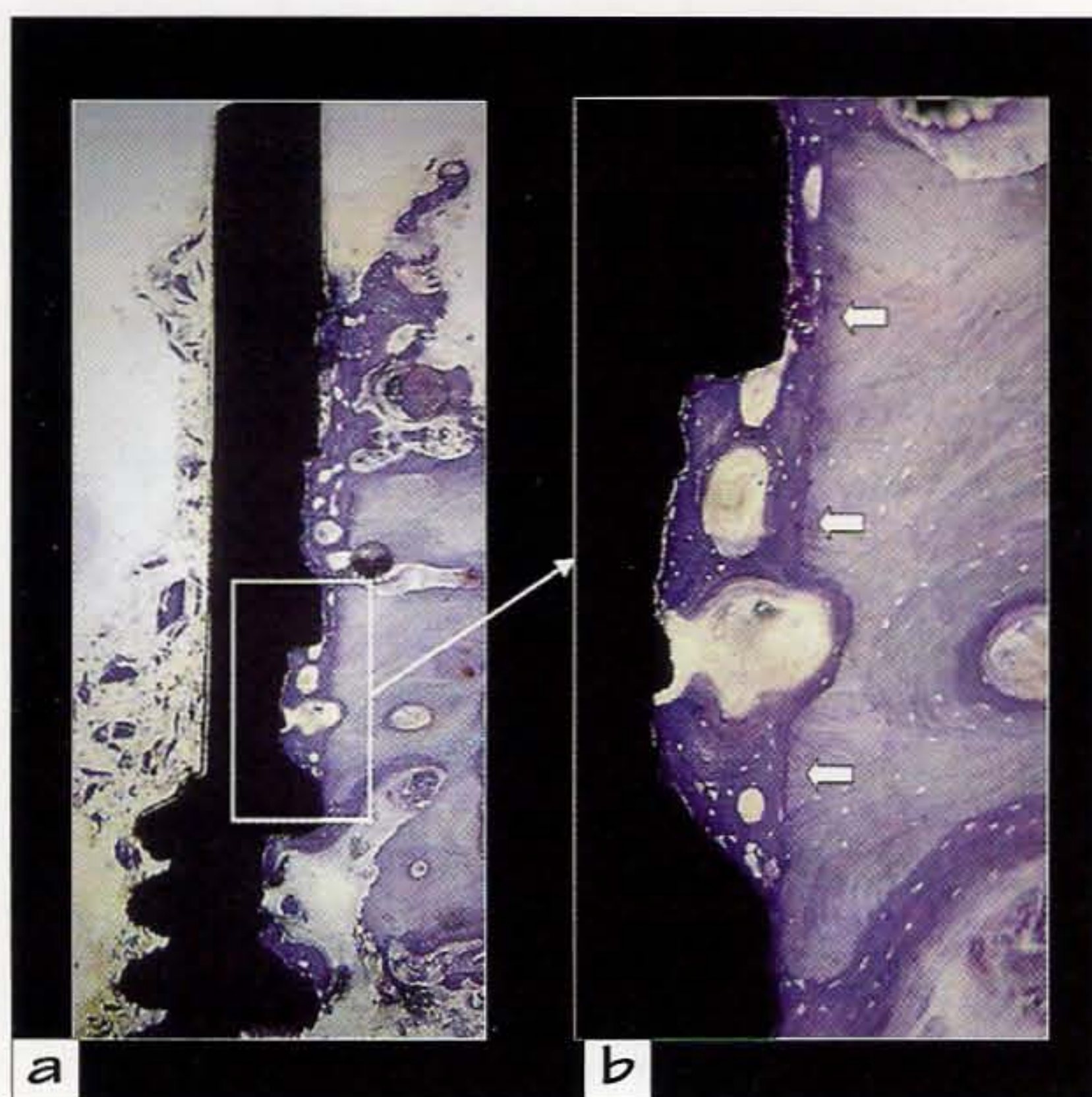
The first suggestion that immediate loading could be feasible was the discovery of a threshold level for toleration of micromovement^{9–11} (Table 2-3). Below this threshold, bone healing occurs undisturbed; above it, bone healing is disrupted. It appears that when excessive micromovement is locally present, stem cells cease differentiating into osteoblasts and detour into a route that transforms them into fibroblasts.³⁵ In addition, excessive micromovement induces bone resorption

TABLE 2-3 Principles of immediate loading

Principle	References
A threshold of tolerated micromovement exists. Therefore, acceptable micromovement can be distinguished from harmful micromovement.	7–9
The tolerance threshold for micromovement is surface dependent.	10–12, 34



▲ **Fig 2-1** Physiology of bone healing according to Brånemark.²⁸ A zone of osseous necrosis invariably forms at the osteotomy site. (a) Situation immediately after implant placement. (1) The implant is immobilized in the bone. (2) A hematoma is contained within the space delimited by the implant threads. (3) A damaged osseous zone is invariably created by mechanical and thermal trauma. (4) Undamaged bone is located further away. (5) Implant (black). (b) Phenomena taking place during the stress-free healing period. (6) The hematoma is transformed into bone through the calcification process. (7) The damaged bone also heals in a process of demineralization and remineralization. (c) Situation at the end of the healing period. (8) Osseous remodeling has taken place at the interface in response to the transmitted masticatory forces. (Reprinted with permission from Brånemark.²⁸)



▼ **Fig 2-2** Histologic section of an immediately loaded implant harvested after 10 weeks of loading in a human.³⁰ (a) Implant placed in cortical bone. The drill cut can be clearly identified, separating the old bone (light blue) from the newly formed bone (deep blue). (b) Same section at a larger magnification. The presence of the demarcation (arrows) demonstrates that bone apposition began as a form of bone modeling without passing through the stage of remodeling of necrotic bone. (Courtesy of Dr P. Trisi.)

and replacement by fibrous tissue.³⁴ Accordingly, when the implant is subjected to occlusal loading during the healing period, osseointegration can be obtained merely by maintaining the micromovement within the tolerated limits (Fig 2-3).

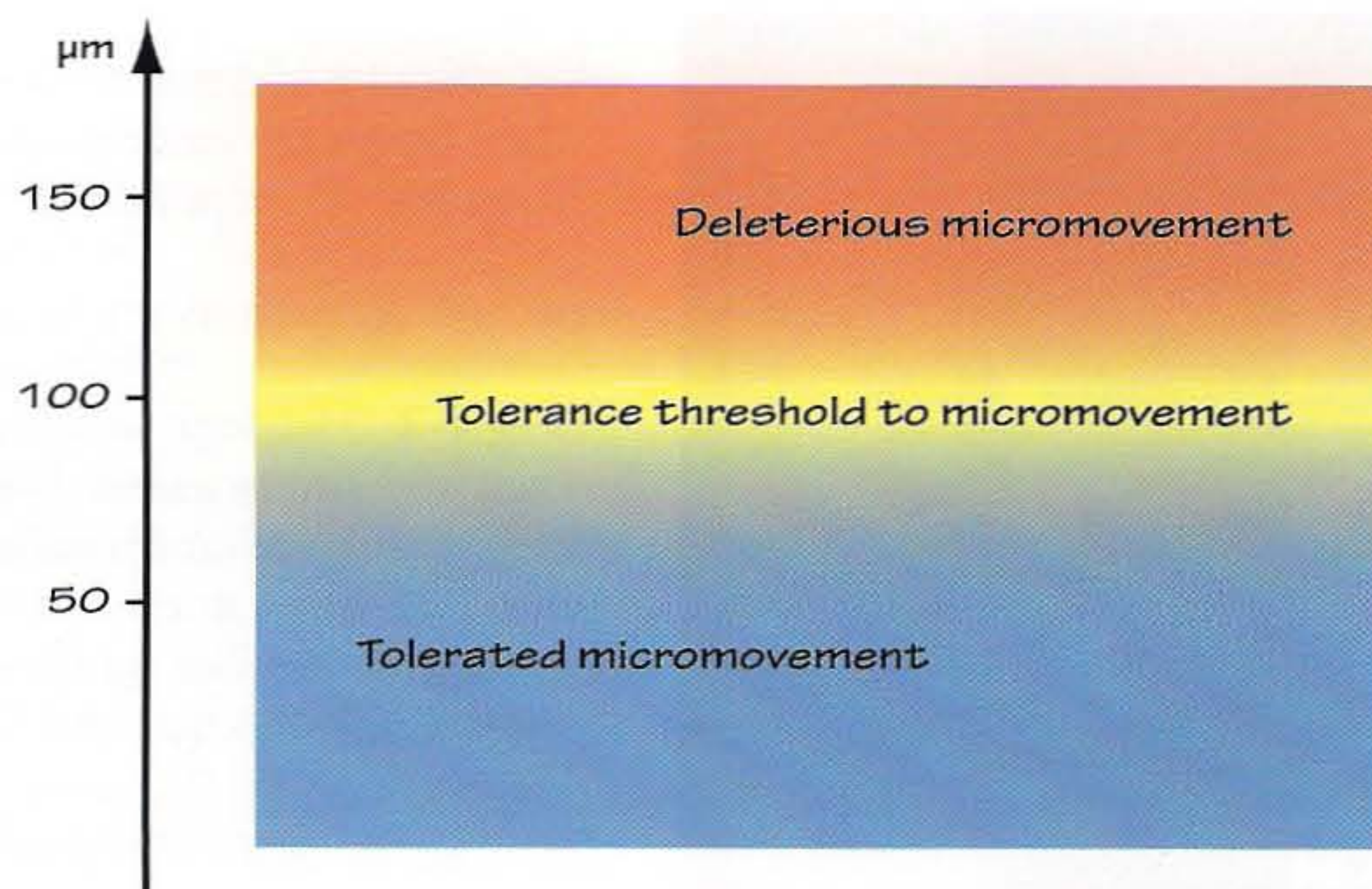
The second concept in support of immediate loading is the fact that the tolerance threshold for micromovement is surface dependent.^{10-12,34,36} Machined surfaces have the lowest tolerance for micromovement, less than 30 μm (Fig 2-4).⁷ The tolerance threshold for roughened surfaces, such as those obtained by titanium plasma spraying, is higher. This threshold has not yet been precisely determined, although it is known to be between 50 and 150 μm (see Fig 2-4).^{9,37} The tolerance threshold is highest for bioactive surfaces such as those obtained with a plasma-sprayed hydroxyapatite coating. Again, the exact limit has not yet been determined, although it is known to range between 250 and 500 μm .^{37,38}

Plasma-sprayed hydroxyapatite-coated surfaces are less commonly used today because of the distrust practitioners developed for these materials during the 1980s and 1990s. The first generation of bioactive implants achieved high success rates by the end of the healing period, especially when placed in sites in which the bone quality or quantity was poor.³⁹ On the other hand, the long-term failure rate, after 5 years, was greater.⁴⁰ This was attributed to extensive, difficult-to-contain peri-implantitis that derived from contact between the bioactive coating and dental plaque.⁴¹ New bioactive surfaces, now prepared with nanotechnologies, have been appearing on the market (eg, NanoTite, Biomet 3i). These implants should exhibit higher tolerance of micromovement without the drawbacks of the plasma-sprayed bioactive coatings.

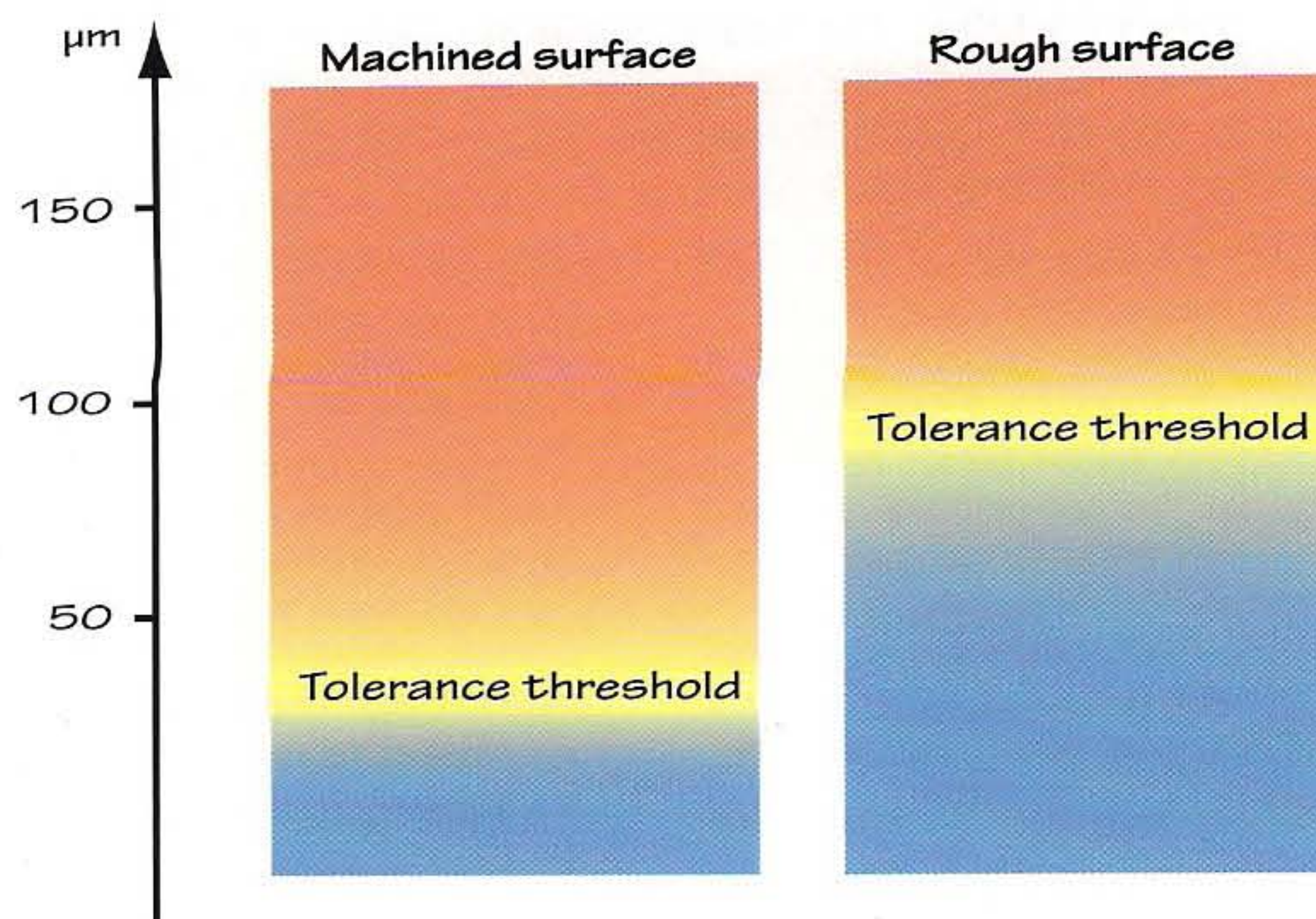
Curiously, the relationship between biomechanical loading and the extent of micromovement at the interface has been poorly investigated. It was found that micromovement of 100 μm in an axial direction resulted from approximately 13 to 16 N of force, a figure that varied with implant design and bone quality⁴² (Fig 2-5).

A recent study⁴³ has documented that the quality of bone at the implant site influences the amplitude of lateral micromovement:

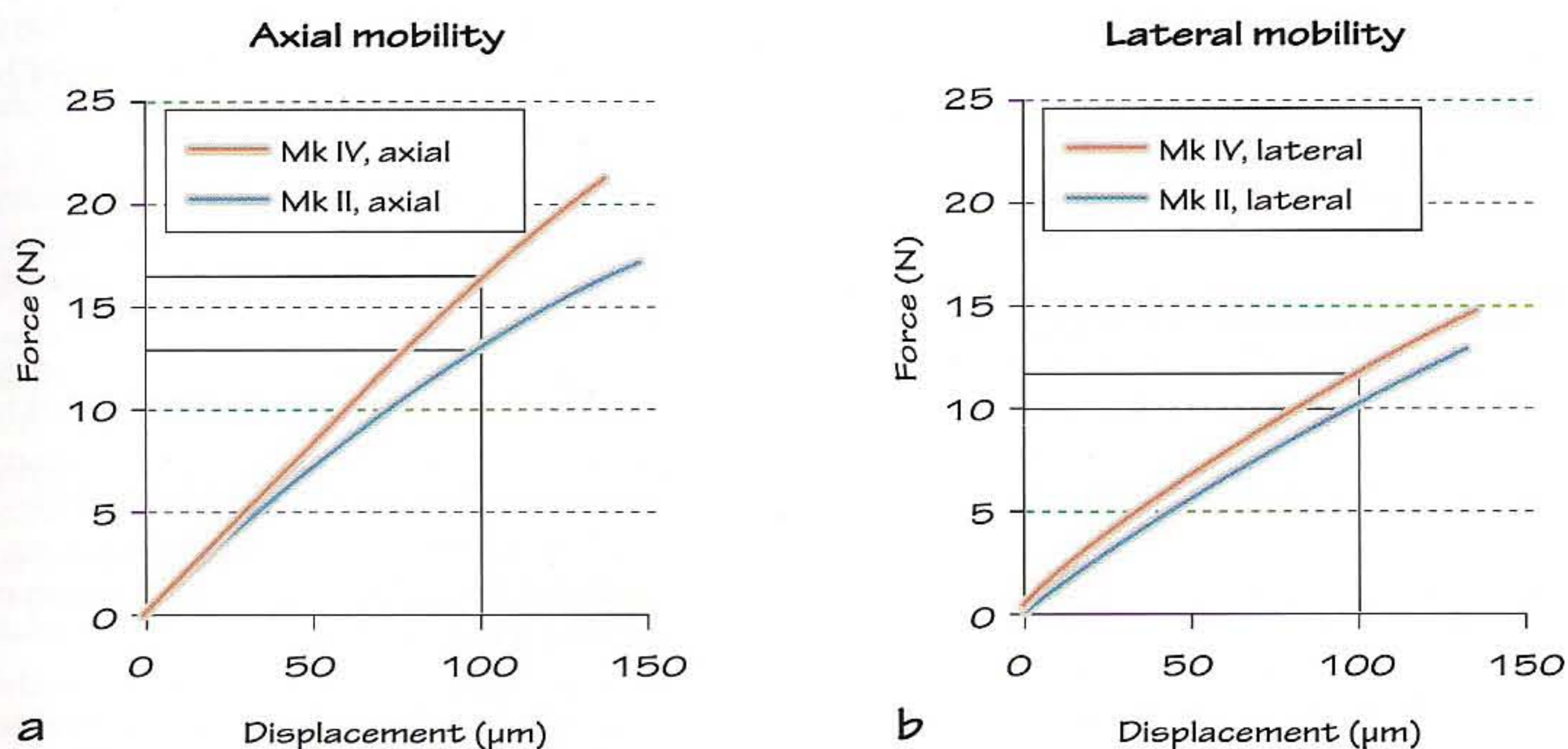
- In type 1 bone, a force of 30 N causes no detectable micromovement.
- In type 2 bone, forces of 5 to 20 N produce micromovements of 20 to 50 μm . The critical threshold of 100 μm is reached when 30 N of force is exerted.
- In type 3 bone, forces of 5 to 20 N cause displacements on the order of 50 μm . On the other hand, 30 N of force produces a displacement greater than 150 μm —about 170 μm .
- In type 4 bone, forces of 5 to 20 N do not cause more than 100 μm displacement, but 30 N will induce a displacement of 200 μm .



▲ **Fig 2-3** Tolerance threshold to micromovement. The tolerance threshold (yellow) delineates where acceptable micromovement (blue) transforms to deleterious micromovement (red).



▲ **Fig 2-4** Relationship between the implant surface and tolerance to micromovement. For machined surfaces, the tolerance threshold is less than 30 μm . For rough surfaces, it is less than 150 μm ; it was empirically estimated to be 100 μm .³⁶ The tolerance threshold (yellow) delineates where acceptable micromovement (blue) transforms to damaging micromovement (red).



▲ **Fig 2-5** Relationship between exerted force and micromovement, measured in vitro.⁴² (a) Relationship when force is exerted along the vertical axis of the implant. The relationship varies depending on the implant design, which differs between the implants Mk II and Mk IV (Nobel Biocare), the latter of which has a flared neck. A force of 13 to 16 N generates 100 μm of micromovement. (b) Relationship when force is exerted laterally, perpendicular to the axis of the implant. The relationship varies depending on the implant design. A force of 10 to 11 N generates 100 μm of micromovement. (Courtesy of J. B. Brunski.)

The vertical forces exerted on implants vary according to the location of the implant site. They are greater in the posterior region of the mouth than they are in the anterior segment. Maximal forces vary from 155 to 565 N.⁴⁴ Lateral forces are weaker, ranging from 18 to 30 N.⁴⁵ Thus, to compile a working protocol for immediate loading of implants, it is only a matter of controlling forces according to determined limits! This is discussed in detail in chapter 4.

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Chapter 3

DIFFERENCES BETWEEN TRADITIONAL AND IMMEDIATE- LOADING PROTOCOLS

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▼ **Participants and Their Roles in Treatment**

The difference between immediate- and delayed-loading protocols resides primarily in the drastic reduction of the time between placement of the implants and delivery of the prosthesis. This condensation of the treatment sequence requires more meticulous management of every step in the procedure. It demands that all participants in the immediate-loading procedure diligently fulfill their roles. Scrupulous planning of each stage is crucial.

The participants in treatment include:

- The patient
- The surgeon
- The prosthodontist
- The dental technician

Reminder:

In practice, the surgical and restorative phases can be managed by either (1) two different specialists, an oral surgeon and a prosthodontist, or (2) a single practitioner who both performs the surgery and prepares the prosthesis. The problems of coordination increase when the necessary inclusion of a laboratory technician makes this a three-person team. Management is simplified when only two actors take part in the treatment. To provide a thorough description of all these situations, the surgical and the prosthetic phases have been clearly and systematically differentiated in these chapters. All aspects of the surgical phase have been assigned to the surgeon and all aspects of the prosthetic phase to the prosthodontist. Practitioners who perform both functions will envision themselves in both roles as they read.

Each participant gets involved at a given point as the treatment proceeds. In the traditional protocol, the actors do not have to rush onto the stage at a precisely defined moment. Figure 3-1a illustrates the sequence and timing of steps for each participant in the traditional rehabilitation of an edentulous mandible.

In the immediate-loading protocol, the surgeon, the prosthodontist, and the laboratory technician either intervene immediately, one after another, during the same appointment, or intervene one after the other over several visits. All the providers have to conform to a rigid schedule. They must all be prepared to play their parts in advance. This requires careful management of the type and the timing of interventions. Precisely because the surgeon and the prosthodontist work simultaneously, they must already have thought of everything and continue to think about everything. Figure 3-1b shows an example of the chronology of steps in an immediate-loading protocol for restoration of the edentulous mandible.

When the same practitioner both performs the surgery and prepares the prosthetics, the problems of coordination are reduced because they involve only the laboratory. When the laboratory is part of the dental practice or located nearby, management is further simplified and delays are minimized.

The roles of the participants in immediate-loading treatment are discussed in more detail in the following sections.

Patient

The patient has to agree to a date for the commencement of treatment. For a delayed-loading protocol, the patient can decide on the scheduling of the second surgical procedure at the completion of the healing period. In addition, he or she can decide when the definitive prosthesis will be placed.

For an immediate-loading protocol, the patient has to submit to the requirements of treatment:

- The operative time is markedly increased when the prosthetic phase follows immediately after the surgery in the same appointment.
- The patient most likely will have to dedicate an entire day to the procedure.
- The needs of the prosthodontist will determine when the provisional restoration is inserted.

On the other hand, the appointment for the placement of the final prosthesis can be scheduled at the patient's convenience, just as in the conventional protocol.

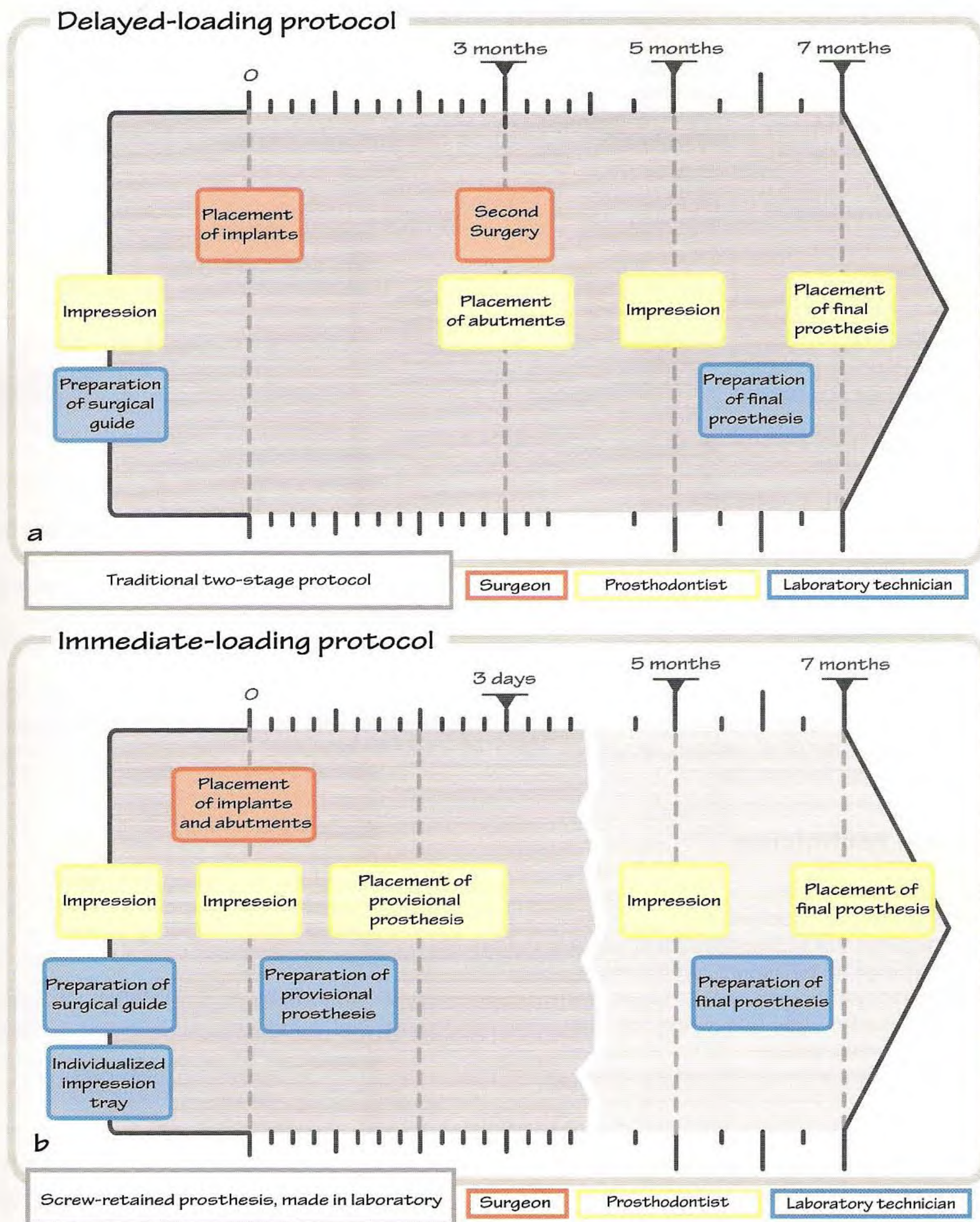
Surgeon (or the surgical phase)

The surgeon accomplishes the surgical phase just as he or she does for a traditional protocol. The surgeon can later direct the prosthetic phase, if desired. The surgeon:

- Conducts the preliminary clinical examination
- Undertakes the radiographic study that evaluates the amount of available bone
- Places the implants with or without preliminary extraction of teeth
- Decides whether the implants can be loaded immediately
- Takes any impressions that may be needed during the surgery
- Places the healing or transgingival abutments
- Organizes and supervises the follow-up of the patient during the healing period
- Decides when the final prosthetic phase can begin

For an immediate-loading protocol:

- Implants of varied lengths and diameters must be available in case those planned for the procedure prove unsuitable as the operation progresses.
- The primary stability of the implant is essential. The insertion torque must be 35 Ncm or greater.
- The implant with the design that will provide the greatest stability must be chosen.
- In the esthetic zone, soft tissues must be handled atraumatically during surgery and they must be prepared for a correct soft tissue emergence profile.



▲ Fig 3-1 Sequence and timing of steps in the treatment of an edentulous mandible. (a) Sequence for a two-stage delayed-loading protocol. The time periods that elapse between the stages are neither counted nor limited. The participants in the procedure perform their assignments in their proper turn, so logistic management poses no real difficulties. (b) Sequence for an immediate-loading protocol in which the provisional prosthesis is placed within 24 hours after the surgery. The treatment team members have to intervene promptly, one after the other, to provide the prosthesis within 24 hours. The logistics of the protocol are more demanding than those of the standard delayed-loading procedure. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Prosthodontist (or the prosthetic phase)

The prosthodontist takes responsibility for the prosthetic portion of the treatment (although, the surgeon may also perform the entire treatment). The responsible practitioner:

- Takes appropriate impressions before implant placement
- Takes postoperative impressions so that the prosthesis can be prepared in the laboratory, when an indirect technique is chosen
- Prepares and places the prosthetic components
- Prepares the prosthesis at chairside, when a direct technique is chosen
- Places the provisional prosthesis
- Adjusts the occlusion of the provisional prosthesis (leaving it in or out of occlusion, in accordance with the specific needs of the case)
- If in charge of postoperative care, examines the patient postoperatively as often as necessary to ensure that healing proceeds smoothly
- Takes impressions for the final prosthesis
- Places the final prosthesis
- Adjusts the occlusion of the final prosthesis

For an immediate-loading protocol:

- The prosthetic components (impression copings, implant analogs, provisional abutments or cylinders, etc) must be prepared in advance.
- Additional materials (straight or angulated abutments) must be available in case the prepared components are found to be unsuitable.
- The schedule should be arranged to accommodate a longer appointment if it becomes necessary.
- The reliability and the availability of the laboratory play a key role in logistic planning for immediate loading when the indirect technique is used. For the protocol to succeed, the participation of a skilled laboratory, able to quickly fabricate an accurate provisional prosthesis, is essential.

Dental technician

The dental technician:

- Prepares the study casts
- Prepares the radiographic and surgical guides
- Prepares an individualized impression tray
- Fabricates the provisional prosthesis (hollowed acrylic resin crown or fixed partial denture, abutments, metal reinforcing bar, cast or not, and cast metal framework) either before or after implant placement
- Fabricates the final prosthesis as usual

For an immediate-loading protocol:

- The provisional prosthesis must be prepared in a short period, from a few hours to 72 hours after surgery. The speed with which it is prepared dictates the amount of time that elapses between implant placement and loading.
- The laboratory technician must be able to devote the time required to finish the provisional prosthesis.
- The components of the prosthesis must be prepared in advance.
- Additional materials must be available in case the prepared provisional restoration or any of its components is found to be unsuitable.

Coordination between participants

It might seem that coordination between the participants is a small matter or easily arranged. However, a much greater level of coordination is needed for these protocols, especially when the surgical and the

prosthetic duties are not fulfilled by the same person. Good communication will prevent missteps when procedures have to be carried out rapidly and almost concurrently. Open channels of communication will also permit complications to be addressed calmly and effectively.

Communication between the surgeon and the prosthodontist

Prior to the surgery, the surgeon and the prosthodontist must:

- Agree that immediate loading is possible in the case at hand and be able to devote the time required for successful implementation.
- From the start, plan and prepare alternative treatment approaches if complications or unexpected impediments make it impossible to proceed with immediate loading.
- Decide whether the provisional prosthesis will be screw retained or cemented.
- Determine whether the provisional prosthesis will be made at chairside or in the laboratory.
- Determine whether the final prosthesis will be screw retained or cemented.
- Determine which prosthetic elements must be available at the time of implant placement.
- Determine which practitioner should have what responsibilities on the checklist.
- Inform all participants of the implant and prosthetic components that have been selected and their specifications.
- Determine the timing of the procedures to be completed by each participant.
- Plan for any delays that may result from surgery.
- Plan the logistics of the patient's movement from the surgical treatment site to the prosthetic treatment site.
- Decide which practitioner will be responsible for control and follow-up examinations.
- Decide who will give detailed home care instructions to the patient.

Communication between the prosthodontist and the dental laboratory

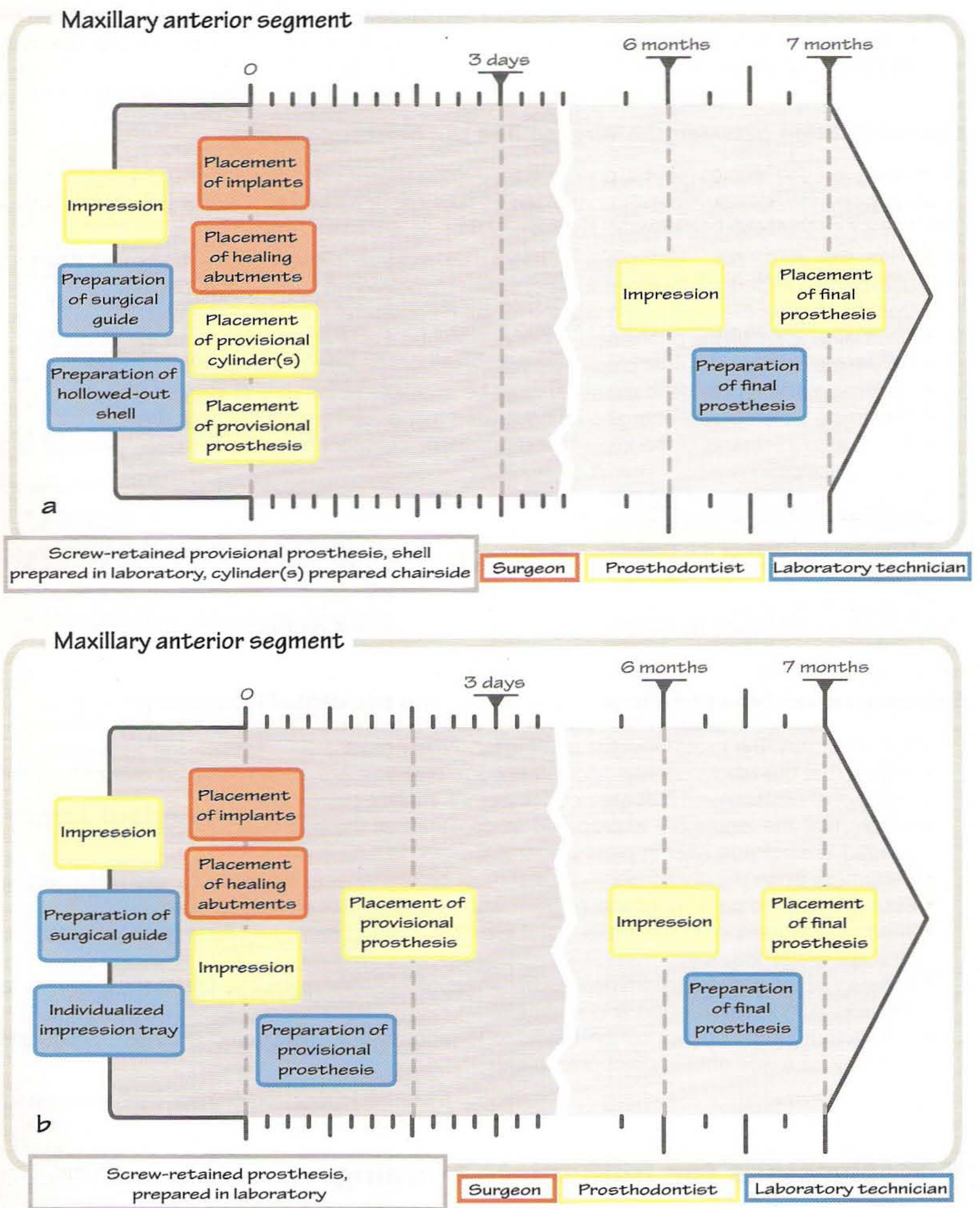
Prior to the surgery, the prosthodontist and the laboratory must:

- Ensure that the laboratory has allowed enough time to make all the required elements of the provisional replacement that are needed before implant placement.
- Ensure that the laboratory is prepared to construct all the prosthetic elements that may be needed immediately after implant placement.
- Determine those prosthetic elements that must be available at the time of implant placement.
- Determine which participant should have what responsibility on the checklist.
- Inform the laboratory of the implant and prosthetic components that have been ordered and their specifications.
- Ensure that the plan for the immediate transmission of impressions and prosthetic elements to the laboratory is established and workable.
- Ensure that the laboratory will be available to process any unexpected emergency requests that may be made after implant placement.

▼ Motivations for Immediate Loading

Depending on the type of oral treatment the patient seeks, immediate loading may be the best response to a variety of motivations, including:

- *Esthetics*: The patient may not wish to remain or become edentulous after the beginning of implant treatment.
- *Availability*: The patient may want the restoration to be inserted promptly for reasons of time management.
- *Optimal healing*: The aftereffects of surgery—pain, edema, and the uncontrollable stresses and forces directed against implants—are easier to manage with a fixed restoration than with a removable prosthesis.



▲ **Fig 3-2** Different sequences and timing of steps in immediate-loading protocols for the maxillary anterior segment. (a) Sequence when the prosthetic phase immediately follows surgery. The provisional prosthesis is prepared before the surgical procedure. No impression is taken immediately after surgery, and the laboratory does not play any role after implant placement. (b) Sequence when there is a delay between surgery and prosthetic placement. An impression is taken immediately after implant placement, and the prosthesis is made within 72 hours. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

- *Convenience and simplicity:* It is easier for patients and practitioners to manage a fixed provisional restoration than a removable one. The frequent and repetitive relining of removable appliances is avoided.
- *Finances:* In some cases, the immediate placement of a final prosthesis eliminates the fees associated with a provisional restoration.

Depending on the wishes of the patient and the clinical situation, a given immediate-loading protocol may be more suitable than another. This greatly changes the sequence and timing of activities for each of the participants in the treatment:

- The prosthetic phase may directly follow the surgical procedure or there can be a certain time gap between the phases (Fig 3-2).
- The prosthetic laboratory may deliver the provisional prosthesis before surgery or after surgery, within 48 to 72 hours.
- The prosthodontist may take impressions before or after surgery.

These sequences will be more precisely described for each indication and prosthetic treatment option.

Principal determinants of treatment

The conditions that orient an immediate-loading protocol toward one trajectory rather than another constitute the principal determinant of treatment. Four such determinants—psychologic, physical, economic, and temporal—have been identified.

Psychologic needs

The patient's psychologic issues exert a powerful influence on the time frame for implant treatment. In cases of failing fixed partial prostheses or tooth extraction after trauma, some patients, for psychologic reasons related to self-esteem, do not want to be deprived of a fixed replacement, even for a moment.

To satisfy this type of urgent request from a patient, implants have to be loaded immediately after placement. The provisional restoration is prepared in one of the following ways:

- In the laboratory before implant placement as an acrylic resin shell
- At chairside following implant placement
- At the nearby laboratory while the patient waits in the dental office

By making the prosthesis chairside, instead of having the laboratory prepare it in advance, the prosthodontist expends added chair time. This option may be more expensive for the patient than having the laboratory fabricate the provisional prosthesis.

Physical comfort

The patient's physical comfort is another contributing factor to the establishment of a specific schedule. For the edentulous mandible, for example, the combined total chair time for completing the successive surgical and prosthetic appointments extends from 3 to 5 hours. For some patients, this lengthy session may be difficult to endure. The solution may be to allow for a sufficiently recuperative rest period between two separate, more endurable appointments.

Economics

Economic factors may also play a role in determining the chronology, as well as the modalities, of immediate-loading treatment.

To cut costs, the provisional prosthesis can be made by the laboratory instead of the dentist at chairside. However, this option will impose a delay between implant placement and delivery of the

restoration. This postponement could last from a few hours for the fabrication of a single crown to 2 to 3 days for the construction of a complete prosthesis with a metal framework.

Moreover, to minimize expenses, elements of the provisional prosthesis, the titanium abutments for example, can be utilized in fabrication of the final prosthesis. However, this option will deprive the patient of replacement teeth while the final prosthesis is being made.

Another cost-saving procedure that can be considered is immediate placement of the final prosthesis without the use of any provisional restoration. However, this choice is possible only when the conditions of osseointegration, such as strong primary stability and a reduced amount of stress at the implant-bone interface, are optimal. In addition, soft tissue management must also be simple without any contraindicating esthetic issues, which is usually the case in the edentulous mandible.

Duration of treatment

The total duration of treatment is a factor in determining the chronologic order of each step as well as the prosthetic options. Some patients have to travel significant distances for their appointments and others have to suspend medications, such as anticoagulants, for surgical procedures. For these patients, shortening the treatment is mandatory. To satisfy this requirement, the treatment team must also be more flexible than usual. In exchange, to accommodate these concessions, treatment costs may have to be greater.

▼ Cost Comparisons

Every treatment has a cost, so it is important to know whether immediate loading is, per se, more expensive than traditional treatment or whether it just represents a (considerable) change in the treatment schedule that does not necessarily incur additional costs.

The comparison should be made by assessing all phases of treatment, including both provisional and final prostheses. The initial appointment for immediate loading may be longer than any other, especially when the prosthetic phase is contiguous with the surgical phase. However, immediate loading requires far less chair time for postoperative and post-prosthetic placement examinations than does delayed-loading treatment.

To carry out this comparison three types of costs must be evaluated:

1. Materials or "hardware," including the implants, the prosthetic elements (abutments, cylinders, extensions, and gold screws), and the laboratory components (transfer copings, abutment or implant analogs, and laboratory screws)
2. Elements prepared in the laboratory, such as the radiographic guide, the surgical guide, the individualized impression tray, the provisional prosthesis, and the final prosthesis
3. Total time required for completing treatment, including the treatment planning and preparatory phase, the surgical phase, the provisional phase from implant placement to final prosthesis fixation, the adjustment of the provisional prosthesis, planned recall examinations, and unplanned emergency or follow-up visits

To illustrate this evaluation, two distinct cases will be presented. One case involves restoration of the edentulous mandible with six implants, and the other involves restoration of a single tooth in the anterior maxilla. Estimates involve chair time and components. The time required for the surgical and prosthetic phases may vary widely, depending on the technical skills of each professional, but these comparisons are based on an average skilled practitioner. Cost estimates are based on components available from Biomet 3i. At the beginning of the learning curve, clinicians should allot the additional time that will inevitably be required for coordinating the efforts of all the participants in the endeavor.

Restoration of an edentulous mandible

The delayed-loading protocol selected for this example is a two-stage submerged protocol with six implants. Two surgeries are involved; provisionalization during the healing stage is provided by a provisional denture that is extensively relieved and relined as needed.

The immediate-loading protocol considered involves the same number of implants and a conversion prosthesis prepared in the laboratory. The process consists of converting, with the assistance of the laboratory, a removable denture into a fixed prosthesis.

Treatment time

More preparation time is required for immediate loading than traditional delayed loading, especially when coordinating the activities of the team is factored in.

The time allotted for implant placement and postoperative examinations is similar, but delayed loading requires the imposition of a second surgical phase.

The time devoted to the provisional prosthesis varies according to the selected protocol. For a delayed-loading treatment, more maintenance visits, usually four to five, are required to relin the denture. With an immediate-loading procedure, these visits are avoided. However, after implant placement, before the provisional prosthesis can be fabricated, an appointment to take an impression is required. The steps devoted to construction of the final prosthesis are identical in the two protocols.

The total time estimate is 11 to 14 hours for a delayed-loading protocol and 7 to 9 hours for an immediate-loading procedure.

Prosthetic and laboratory components

The number of implants needed for both protocols is the same, but immediate loading demands more prosthetic components for its implementation. The fixed provisional restoration requires specific transgingival abutments and their healing caps, provisional titanium cylinders and their gold screws, and extensions should they be needed. For fabrication of the provisional prosthesis in the laboratory as well as the final prosthesis, two identical sets of abutments are needed as well as a set of impression copings. A second set of gold screws is necessary for the final prosthesis.

For the delayed-loading procedure, the prosthetic components are fewer: Only the impression copings and the laboratory analogs are required.

The estimate is that immediate-loading protocols result in a 70% to 90% greater cost for the prosthetic and laboratory components.

Prosthetic laboratory procedures

In both protocols, the laboratory prepares the study casts, the surgical guide, and the impression tray as well as the final prosthesis. For the immediate-loading technique, the laboratory technician makes the removable prosthesis, which will be eventually converted to a fixed one when it is attached to the cylinders, which are screwed to the implants.

The immediate-loading procedure increases the laboratory cost by about 25% compared with delayed loading.

Cost analysis

A comparison of the two protocols reveals that immediate loading:

- Presents the marked advantage of decreasing the chair time for the prosthodontist by one-third, or as much as 4 or 5 hours
- Moderately increases the cost of the laboratory procedures
- Substantially increases the cost of needed hardware

Patients with an edentulous mandible who wish to avoid having to live for 2 months with an imperfectly functioning provisional denture have to pay a substantial cost for immediate loading.

For many patients who are in the process of losing their teeth, this may be an acceptable price to pay for the psychologic comfort provided during the difficult transition from a failing fixed prosthesis to provisional restoration with a removable prosthesis. On the other hand, for patients who have already been edentulous for some time, this 2-month period may present no pronounced difficulties; for them, the savings accrued with a delayed-loading protocol may weigh heavily in the decision.

Replacement of a single crown in the anterior maxilla

In this example of replacement of a single crown, the delayed-loading protocol considered is performed according to the two-stage submerged implant protocol. During the osseointegration period, provisional restoration is achieved with a provisional fixed partial denture bonded to the two adjacent teeth.

The immediate-loading protocol being considered involves a cemented provisional crown placed immediately after surgery. An empty shell is prepared previously in the laboratory. During the prosthetic phase, the prosthodontist prepares the titanium abutment at chairside, adapts the provisional crown to the abutment, and cements the crown. The patient receives an implant-supported prosthesis in one extended appointment.

Treatment time

When the coordination of the participants is considered, it takes longer to prepare for an immediate-loading protocol than it does for a delayed one.

The time allotted for implant placement and for the initial postoperative follow-up is similar in both protocols, but delayed loading requires a second surgery.

In the two protocols, different amounts of time are devoted to the provisional prosthesis. The delayed-loading treatment for a single crown does not require repeated relining of the prosthesis, as would be necessary for the edentulous mandible. However, to obtain access to the implant during the appointments devoted to preparing the final prosthesis, the provisional fixed partial prosthesis must be debonded and rebonded at each visit, a procedure that is always time consuming and sometimes demanding. In addition, these provisional replacements often loosen unexpectedly and have to be rebonded in emergency visits. Preparation of the final prosthesis is identical in the two protocols.

The estimation is that about 6 to 7 hours total are needed for the delayed-loading protocol and 4 to 5 hours are required for the immediate-loading process.

Prosthetic and laboratory components

Both protocols require a single implant, but the immediate-loading procedure demands more prosthetic components than does the delayed-loading protocol. A healing abutment, a titanium abutment or a provisional cylinder, and a gold screw are needed for the provisional crown. The final prosthesis requires a second titanium abutment and gold screw. On the other hand, the delayed-loading protocol requires only an impression coping, an implant analog for the laboratory, a single abutment, and a single gold screw. Material costs are about 10% higher for the immediate-loading protocol.

Prosthetic laboratory procedures

In both protocols, the laboratory prepares the study casts, the impression trays, and the final prosthesis. When loading is delayed, the laboratory constructs a provisional metal-reinforced, resin-bonded prosthesis to bond to the adjacent teeth. In the immediate-loading procedure, prior to surgery, the laboratory prepares a hollowed-out crown shell with positioning wings. Thus, immediate loading reduces the cost of laboratory procedures by about 40%.

Cost analysis

The comparison between the two loading protocols reveals that immediate loading:

- Reduces the chair time for the prosthodontist by 30% to 35%, or about 2 hours
- Reduces the cost of laboratory procedures by about 40%
- Modestly increases, by about 10%, the cost of the hardware

From a financial point of view, immediate loading of a single maxillary crown should result in a similar, or perhaps slightly lesser cost, than a delayed-loading procedure. The psychologic gain, however, is substantial. Immediate loading is therefore economically feasible as a first-choice treatment.

Conclusion

Analysis reveals that the possible cost differences between an immediate-loading procedure and a delayed protocol vary enormously, depending on the indications. For every case, two treatment plans should be carefully outlined and offered to the patient with an explanation of all risks, costs, and benefits. In addition to the financial factor, psychologic concerns play a great and, often, predominant role, in a patient's choice between one treatment protocol and the other.

Chapter 4

STRATEGIES FOR OPTIMIZING OSSEOINTEGRATION

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Micromovement at the bone-implant interface must be minimized,¹⁻³ and the factors that govern it must be identified. These factors can be divided into the following categories (Fig 4-1):

- Properties of the bone site
- Properties of the implant
- Mechanical stresses exerted on the implant

There are two ways to reduce micromovement at the bone-implant interface: Primary stability should be maximized and exerted mechanical stress should be minimized (Fig 4-2). When these two approaches are implemented simultaneously, implant osseointegration is readily achieved. Strategies adopted to achieve this goal depend on whether the fixed prosthesis is complete, partial, or limited to a single crown (Figs 4-1, 4-3, and 4-4).

▼ **Optimizing Primary Stability**

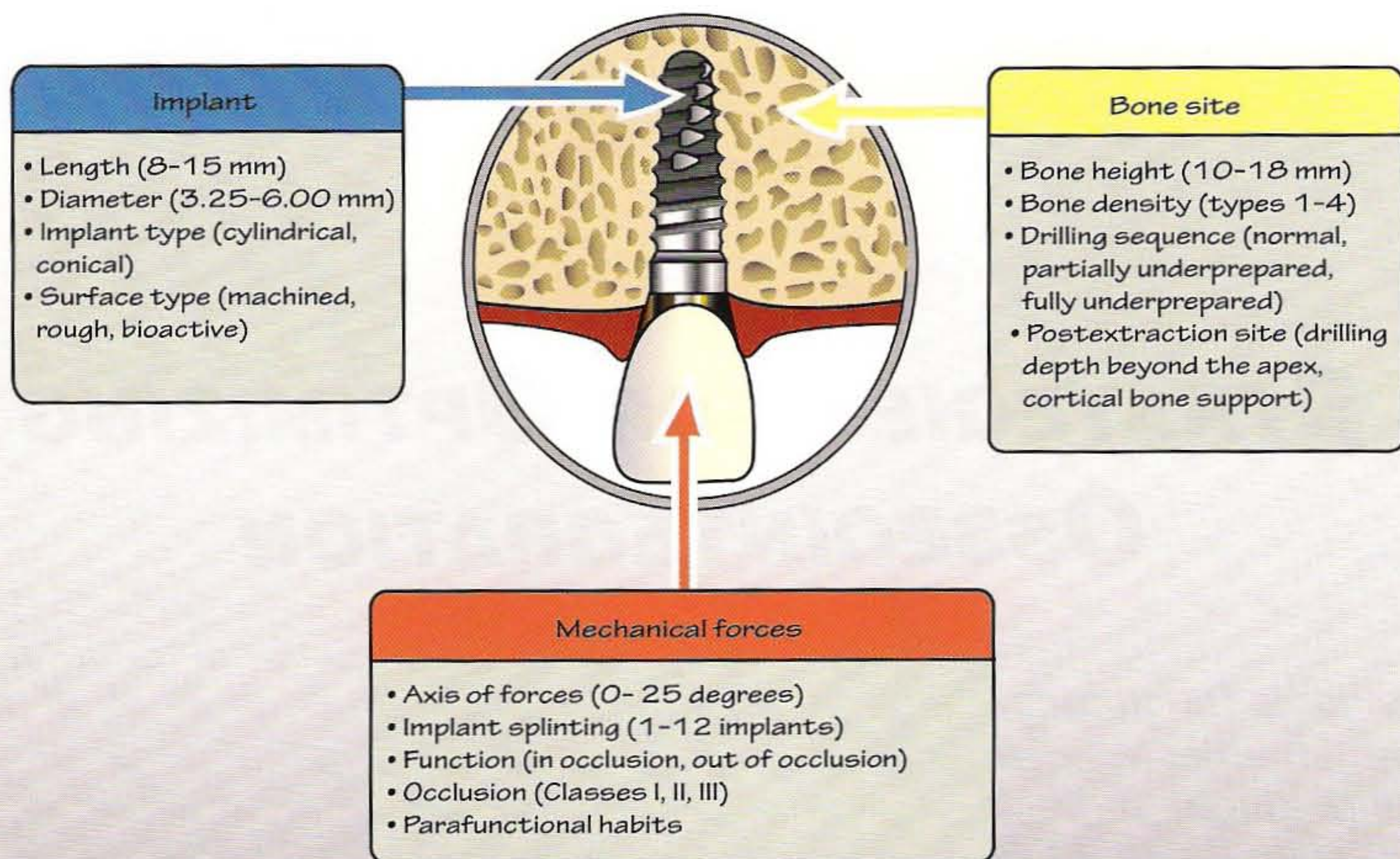
Whatever the loading protocol, primary stability is key to the prognosis for implant integration. For an immediately loaded implant, it is especially crucial to limit micromovement within the tolerance threshold (less than 100 μ m for roughened surfaces⁴). All efforts should be directed at remaining within tolerated levels of micromovement, and the first approach is optimizing primary stability.

After the different methods of measuring primary stability are discussed, the ways it can be increased will be reviewed.

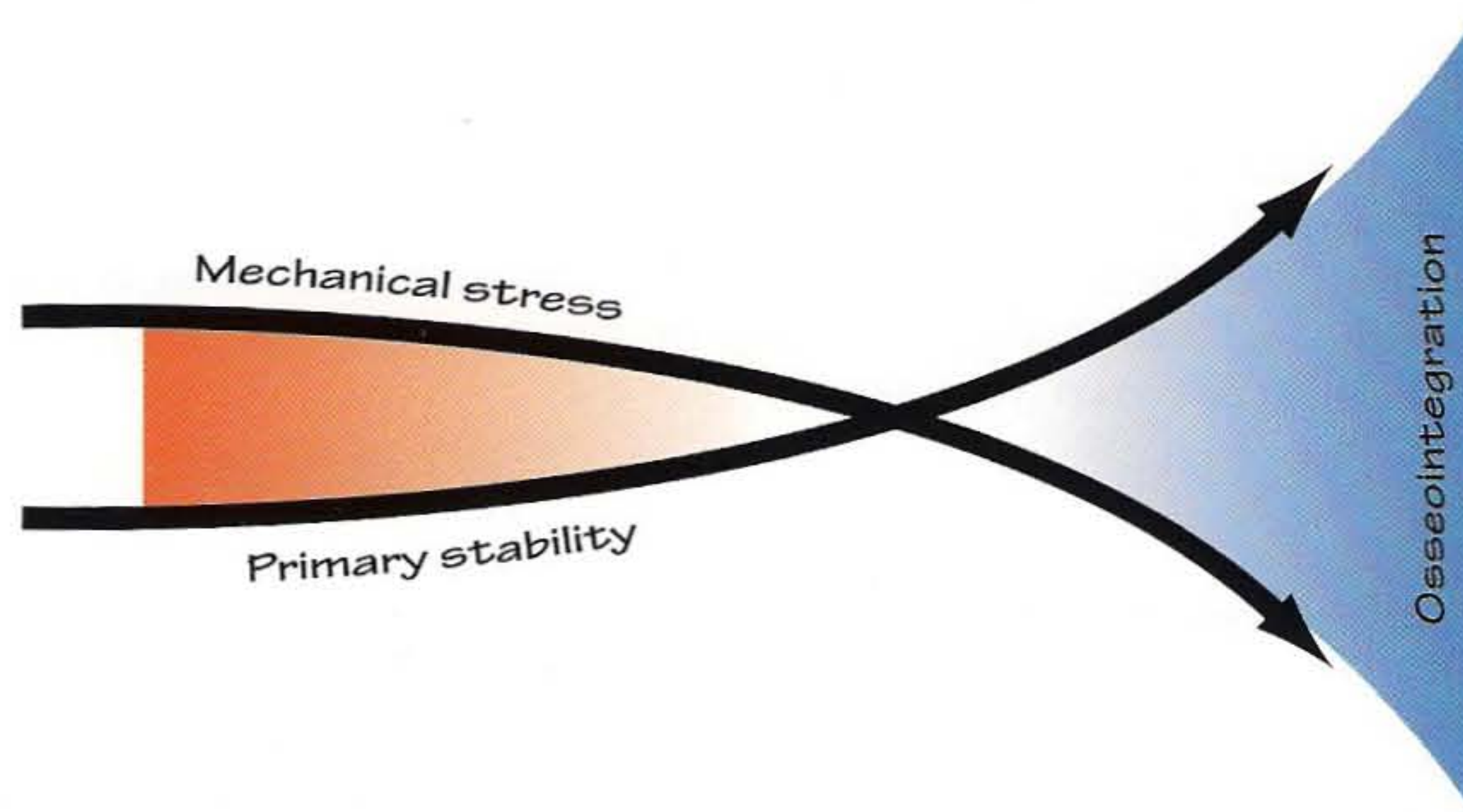
Measurement of primary stability

It is intuitively perceived that implants with greater primary stability are better prepared to resist higher levels of stress. It should be easier for such implants to limit micromovement below the harmful levels that lead to fibrous encapsulation. Knowing this, clinicians would like a reliable method of measuring primary stability. Ideally, such a method would provide a threshold value above which primary stability

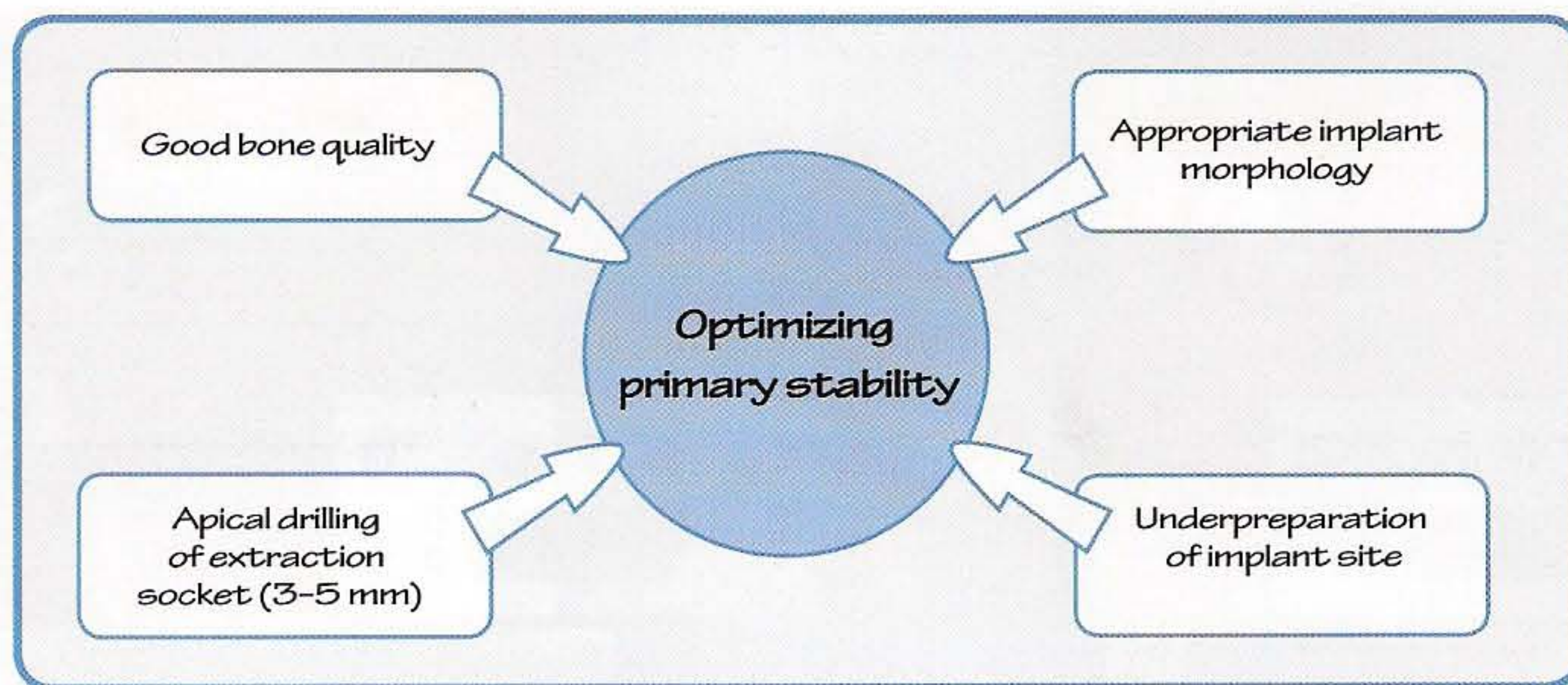
Parameters affecting micromovement at the bone-implant interface



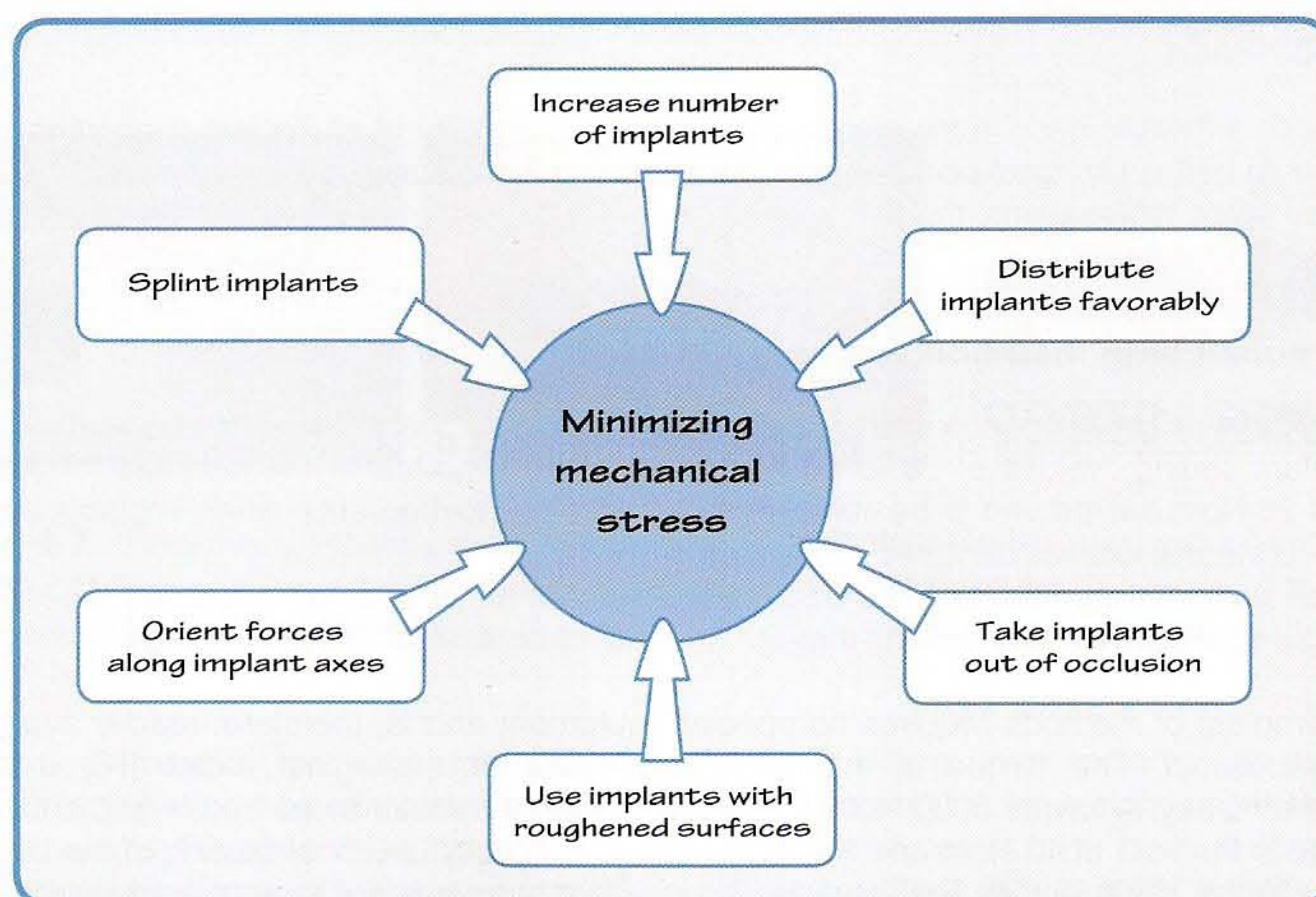
▲ **Fig 4-1** Factors that affect the mechanical stress exerted at the bone-implant interface, categorized according to the bone site, the implant, and the mechanical forces exerted at the coronal part.



▲ **Fig 4-2** Strategies for minimizing micromovement at the bone-implant interface. The goal is to optimize primary stability and to minimize stress at the same time. These concerted efforts can effectively limit micromovement at the bone-implant interface and promote osseointegration.



▲ **Fig 4-3** Factors that optimize the primary stability of the implant.

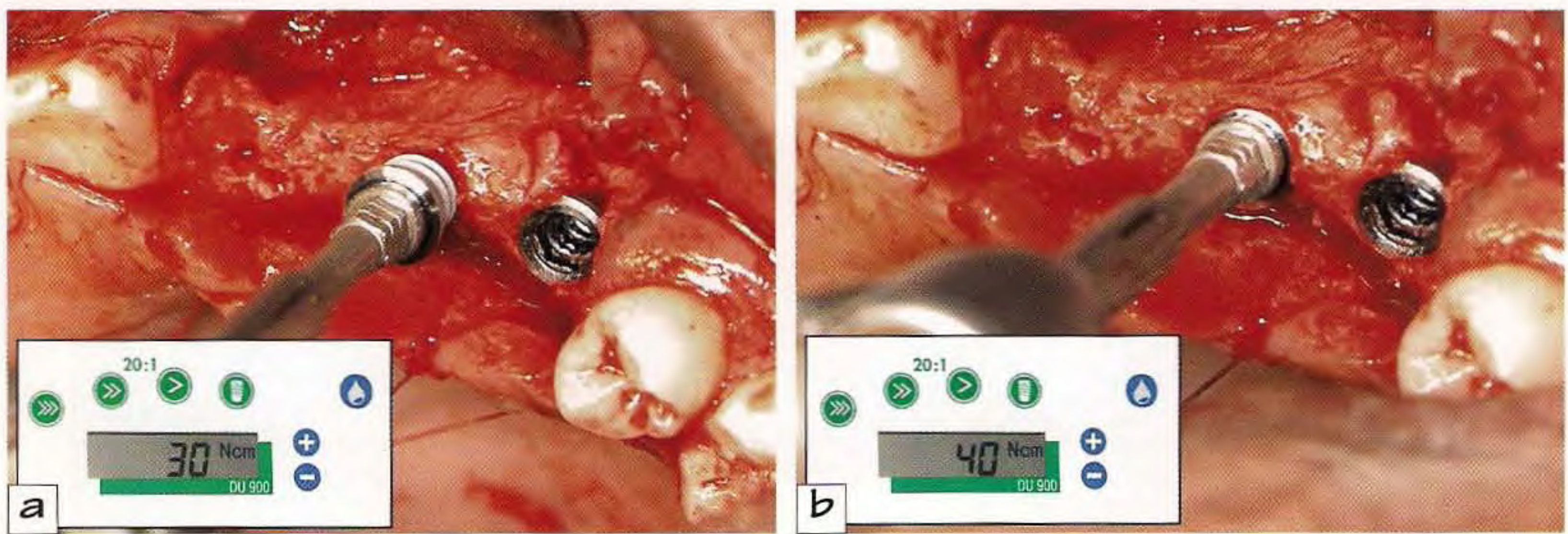


▲ **Fig 4-4** Factors that minimize the mechanical stress exerted on the implant.

could be considered robust enough to be predictive of osseointegration if the implant were immediately loaded. As a corollary, values of primary stability below this threshold would suggest that immediate loading is destined to fail and that osseointegration can be only achieved by means of a delayed-loading procedure.

Unfortunately, no such objective measurement of implant stability yet exists. The methods described in the next few sections offer only indications and furnish only approximate values. Ultimately, the clinician must rely on his or her best clinical judgment in deciding whether or not to proceed with immediate loading.

In addition, achievement of the greatest primary stability should not be considered as an end in itself, because it is just one of the elements that play a role in preventing micromovement from exceeding acceptable limits (see Fig 4-1). In fact, a lesser primary stability can be tolerated if an immediately loaded prosthesis is supported by six to eight implants, bilaterally distributed in a crossarch pattern and



▲ **Fig 4-5** Determination of final stability using insertion torque. (a) Placement of the implant with predetermined torque of 30 Ncm. The motor stops during the course of screwing in the implant. (b) Final seating of the implant. The predetermined torque has been set to 40 Ncm, enough for the implant to be screwed into its final seating.

splinted with a metallic bar. On the other hand, the primary stability of an implant supporting a single crown should be the strongest possible to avoid exceeding the tolerated micromovements.

Despite these reservations, the following paragraphs describe the current ability of clinicians to measure primary stability.

Measurement with insertion torque

The simplest way to measure primary stability is to relate it to the maximal torque applied for the final implant setting. Values of 20 to 50 Ncm have been reported in the literature.⁵⁻⁹ However, torque of 35 Ncm has proved to be sufficient to achieve osseointegration when implants support:

- Complete mandibular dentures^{6,10}
- Small posterior mandibular fixed partial dentures that are kept out of occlusion^{9,11}
- Single anterior maxillary crowns that are kept out of occlusion^{9,12,13}

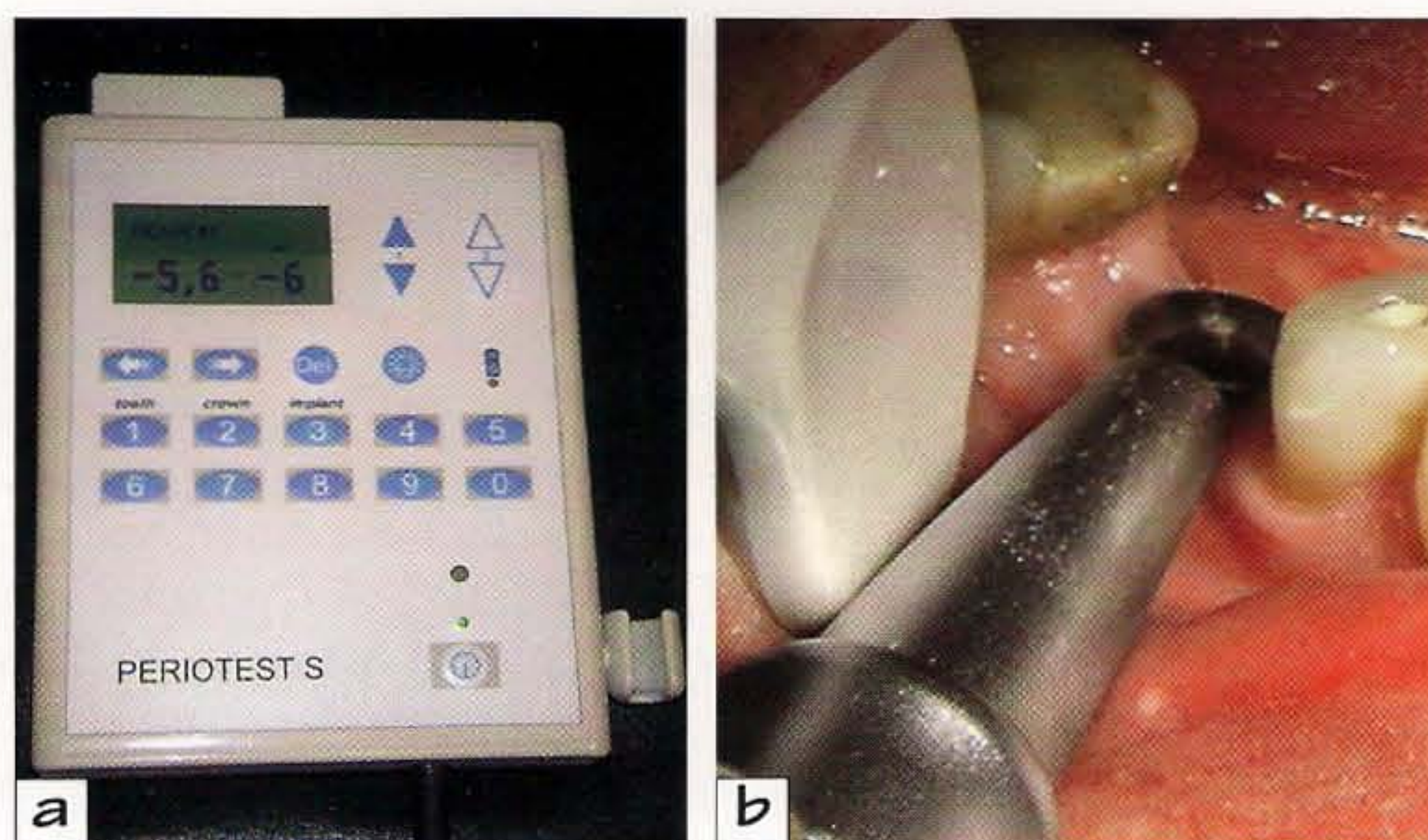
This simplest of methods requires no special equipment and is, therefore, readily available to every practitioner. The torque is measured by means of a surgical motor (Fig 4-5) or a dynamometric key. A torque of 30 Ncm is selected. When the motor stops before implant seating, the torque is then set at 40 Ncm and the motor resumes activity until final seating of the implant. If the motor stops again before final seating, the insertion torque is set to an even higher value to achieve the final seating of the implant.

Measurement with the Periotest

The Periotest (Medizintechnik Gulden) is an electromechanical device (Fig 4-6) developed to measure the mobility of natural teeth.¹⁴ Nevertheless, it has swiftly gained acceptance as a means of quantifying implant stability.¹⁵ In this technique, the tooth or implant being tested is tapped with a small hammer placed in a handpiece set at a predetermined speed (see Fig 4-6). The hammer decelerates in proportion to the stability of the tested object. The deceleration rate is measured electronically and produces an arbitrary value between -8 and +50. The more negative the value, the better the stability. When the test is performed at the end of the healing period, a +9 reading indicates implant mobility and thus failure of osseointegration.

In fact, what is measured in this process is not the stability of the implant in the osseous crest but the resilience of the implant-bone unit. Periotest readings taken at the end of the healing period do not, in any way, provide an assessment of how well the implant is osseointegrated. Moreover, implants with a negative Periotest value might yet be clinically mobile. This artificially negative Periotest value may occur when a loose implant is braced against the cortical bone but not integrated (Szmukler-

► **Fig 4-6** Determining stability with the Periotest. (a) Periotest electronic device. It gives mobility measurements, arbitrarily assigned to a scale between -8 and +50. In this instance, the reading is -6. (b) Periotest handpiece with the hammer tapping an implant. The handpiece must be maintained perpendicular to the long axis of the implant. The implant is tapped at the gingival emergence.



▲ **Fig 4-7** Determining implant stability with the Osstell. (a) Osstell. The device consists of a frequency generator, a wire, and a connector. (b) Vibrating blade screwed into an implant. (c) ISQ reading. The value in itself is not sufficient for a correct reading. The shape of the tracing must also be sharply defined.

Moncler S, Bernard JP, personal communication, 2004). Therefore, even implants with a negative Periotest reading should be ultimately assessed manually to confirm the value of the negative reading.

The threshold Periotest value predictive of osseointegration has not yet been determined for immediately loaded implants. However, immediately loaded implants with an initial stability between + 2 and 0 reportedly have achieved osseointegration.¹⁶

Measurement with the Osstell

The Osstell (Osstell) is an electronic device whose principle is similar to the Periotest. The shockwave used to measure the resilience of the bone-implant unit is generated electronically instead of mechanically (Fig 4-7). The device measures the resonance frequency of the tested entity. An electromagnetic wave vibrates the blade of a transducer screwed into the implant. In turn, the blade causes the bone-implant unit to vibrate in a resonance frequency that the device analyzes.¹⁷ The higher the frequency, the more rigid or stable the structure is considered to be.¹⁸

The stability of the bone-implant unit is assessed by studying variations in the resonance frequency over time.¹⁹ For the sake of simplicity, the Osstell device converts the resonance frequencies into arbitrary figures ranging from 1 to 100, dubbed the Implant Stability Quotient¹⁹ (ISQ). The ISQ is read immediately after implant placement; the higher the ISQ, the more secure the primary stability is deemed to be. However, like the data gained with the Periotest, this measurement assesses neither the rigidity of the implant in the bone site nor the extent of osseointegration but merely the resilience of the bone-implant unit.²⁰

Some authors have suggested that implants with an ISQ greater than 60 can be predictably submitted to immediate loading.^{21,22} However, a recent study²³ has shown the limitations of the ISQ as an indicator for immediate loading. The goal of that study was to establish an ISQ threshold value predictive of the future osseointegration of immediately loaded implants. Although an ISQ threshold value of 54 was established, the threshold did not imply that all implants with lower readings would fail to osseointegrate if loaded immediately. In fact, a number of implants with an ISQ value of less than 54 did achieve osseointegration. The study demonstrated that threshold ISQ values of 54 to 60 are conservative and that practitioners who rely solely on ISQ values deprive a high number of implants (31% in the study) and an even higher percentage of patients (62% in that study) from the benefits of immediate loading. The conservative character of these ISQ threshold values appears even more pronounced when these numbers are used as prerequisites for all implants in cases of immediate rehabilitation.

To guarantee their chances of success, clinicians unfamiliar with immediate-loading protocols can rely on the ISQ threshold of 54 to 60 when deciding whether or not to immediately load implants. However, these practitioners should remember the conservative nature of this threshold and consider immediate loading even for implants with lower ISQ values.²³

Influence of the implant on stability

Length

The longer the implant, the greater the primary stability. The ideal implant length is 10 to 15 mm. Implants shorter than 10 mm are at greater risk; implants longer than 15 mm add nothing to primary stability.

Diameter

A large diameter does not in itself improve implant stability.²⁰ Higher primary stability can be obtained only if one or both cortical plates are engaged when the implant is placed.

Implant type

The implant shape plays a role in its primary stability. Conical implants¹¹ (eg, naturally tapered implants from Biomet 3i) as well as those with wide necks²⁴ (eg, Osseotite XP or Prevail from Biomet 3i) promise greater stability than cylindrical implants and therefore should be preferred in cases of immediate loading. On the other hand, conical implants require precise drilling of the osteotomy site to achieve an exact apicocoronal placement.

Implant surface

The surface and surface treatment of the implant is not a contributing factor to primary stability.²⁵ However, the surface does greatly influence the bone healing process because the tolerance to micromovement is greater for a roughened surface than for a machined surface²⁶ and greater for a bioactive surface than for a roughened surface (see chapter 2). Accordingly, implants with roughened and, if possible, a bioactive surface should be chosen for immediate-loading protocols.

Influence of the bone on stability

Bone height

Longer implants provide greater initial stability, but increasing that length beyond 15 mm adds little benefit. There is, therefore, no reason to look for implant sites with more than 15 mm of bone height available. In the posterior segment of the mandible, a 2-mm safety zone above the mandibular canal should be maintained.²⁷ In the posterior segment of the maxilla, penetration of 1 or 2 mm into the sinus cavity has no adverse consequences.²⁷



▲ **Fig 4-8** Drilling sequence according to the bone quality at the implant site. (a) Drilling sequence for placement of a 5-mm-diameter natural-tapered implant in high-density bone. All the burs, including the screw tap, are used. (b) Drilling sequence for placement of a 5-mm-diameter natural-tapered implant in normal bone. All the burs except the screw tap are used. (c) Drilling sequence for placement of a 5-mm-diameter natural-tapered implant in low-density bone. The final bur and the screw tap are not used.

Implant positioning should avoid perforation of the buccal or palatal plates; implants should be surrounded by a layer of at least 1 mm of cortical bone. Some authors²⁸ have suggested that fenestration of the cortical wall is acceptable if it may increase primary stability of the implant by ensuring implant placement within denser bone. However, this approach requires simultaneous lateral bone augmentation and a barrier membrane, which can be a source of complications. It is therefore inadvisable for inexperienced clinicians to use this technique routinely.

In the anterior area, where esthetics is involved, at least 2 mm of cortical bone should be left around the implant to limit vertical bone resorption and preserve adequate support for adjacent soft tissues.

Bone density

The best primary stability is obtained in regions of dense type 1 bone.²⁰ However, in these sites of highly corticalized bone, remodeling is slower than in spongy bone. The secondary stability obtained through osseointegration arrives only after a long, slow osseous growth process.

Immediate loading can be performed in type 2 and type 3 bone, where primary stability can easily be obtained. However, it should be avoided in type 4 bone.

Postextraction sites

After tooth extraction, the site is cleaned meticulously so that no granulation tissue remains. If the proposed implant does not fill the extraction socket and therefore does not provide good implant stability, drilling an additional 3 to 5 mm beyond the apex will increase primary stability. Conical implants or wide-neck designs are more suitable for an extraction socket.

In the anterior maxilla, the implant often is placed with a greater palatal axial inclination than that of the extracted tooth.²⁹ The aim is to preserve buccal bone and the soft tissue support that is needed for long-term soft tissue preservation and good esthetics.

Influence of the drilling sequence on stability

The primary stability of the implant can be improved by altering the drilling sequence, even in low-density bone.

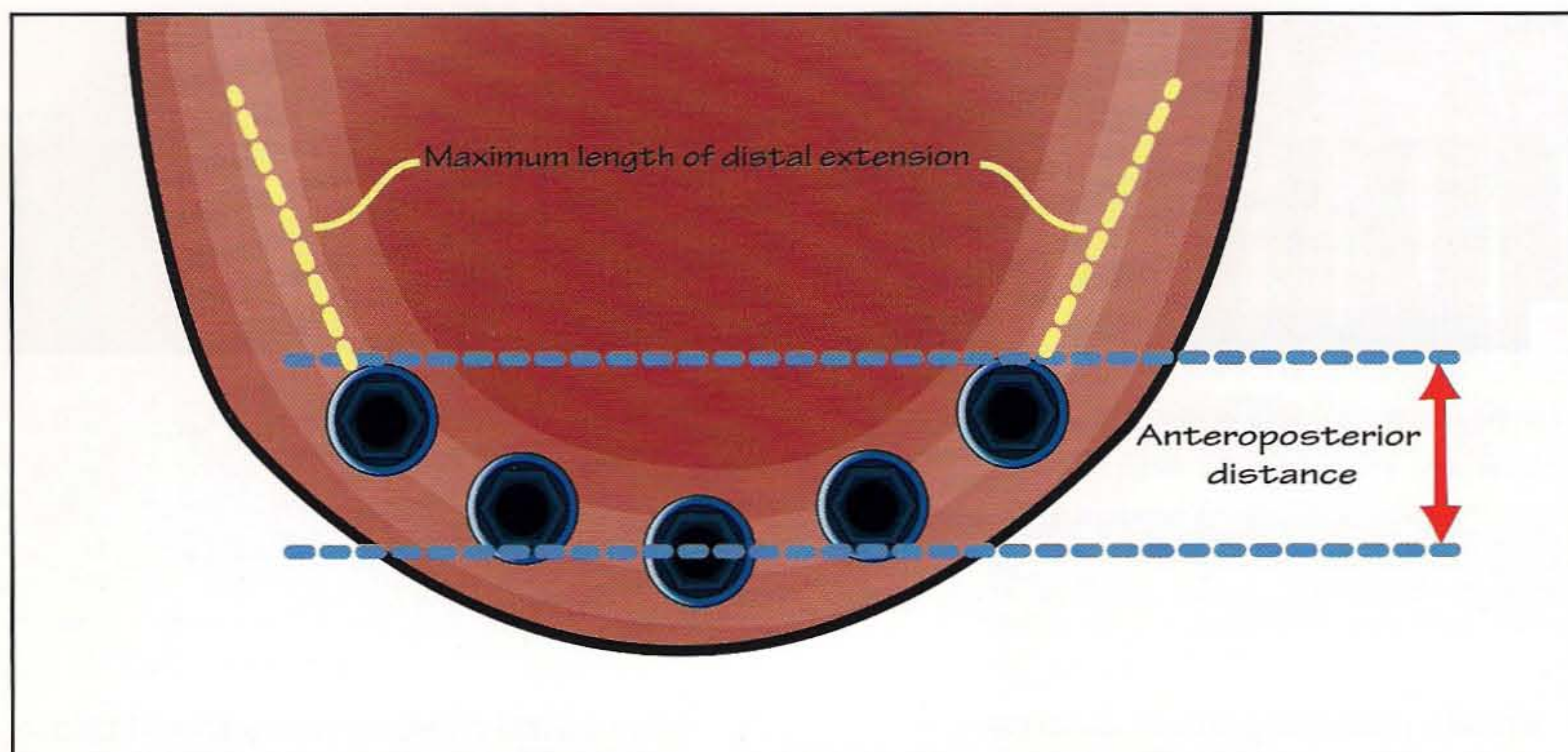
Protocol for drilling in high-density bone

In this sequence all burs, including the screw tap, are used (Fig 4-8a).

Protocol for drilling in normal bone

All burs except the screw tap are used in sequence (Fig 4-8b).





▲ **Fig 4-9** Rule of anteroposterior distance to determine the maximum length of distal extensions. The length of allowable extension is 1.5 times the anteroposterior distance.

Protocol for drilling in low-density bone

In this sequence, the 2-mm bur establishes the depth of the site; it is followed by the first bur corresponding to the implant diameter. The goal in this instance is to underprepare the implant site, without using the final bur and the screw tap (Fig 4-8c). If, during placement of the implant, frictional resistance is elevated and requires torque of more than 50 Ncm to overcome, the implant may be temporarily removed. The site preparation is then finished with the next bur in sequence and the implant is placed, still without use of the screw tap.

▼ Minimizing Forces at the Bone-Implant Interface

The second way to reduce micromovement at the bone-implant interface is to minimize the forces exerted on the immediately loaded prosthesis. There are several ways to reduce forces:

Number of implants

In the partially edentulous arch, the number of implants that can be placed is limited by the available mesiodistal space. In the edentulous arch, however, the number of possible implants can vary from 5 to 10 in the mandible and 6 to 12 in the maxilla. If the number of implants is increased, the forces, distributed proportionately to the group, will be lessened on each implant.

Distribution of implants

The distribution of implants in the arch can help to minimize the stress exerted individually on the implants. The surgeon should seek to achieve the widest possible tripod shape. In the edentulous mandible, this can be achieved by respecting the rule of anteroposterior distance,³⁰ which is the distance between the center of the most anterior implant and the distal aspect of the most distal implant (Fig 4-9). The maximum permissible extension is 1.5 times the anteroposterior distance.

Direction of forces

Bone tolerates best the forces exerted on the long axis of the implant. When the characteristics of a site compel unfavorable axial positioning of an implant, counterbalancing stabilizing factors should be introduced, such as insertion torque of more than 40 Ncm, an increased number of implants, or a design with no distal extension.

Angulation of abutments

Because forces exerted against 15-degree angulated abutments or more are not directed along the long axis of the implant, they generate high rotational moments. Angled abutments are acceptable only if the insertion torque of the supporting implants is greater than 40 Ncm and other stabilizing factors at the bone-implant interface are optimal. As a rule, however, abutments with an angle greater than 15 degrees should be avoided.

Management of forces exerted on the prosthesis

The mechanical stress applied to prostheses is exerted as forces and moments. Moments involve a force, a level arm, a rotational axis, and a rotary effect. An implant can be subjected to three types of moments: along its long axis, around its mesiodistal axis, and around its buccolingual axis (Fig 4-10a).

For osseointegration to occur successfully despite unfavorable mechanical stress exerted during the healing period, the magnitude of micromovement at the bone-implant interface must be kept below the critical threshold. This is achieved when forces and moments exerted on the implants are minimized, for example by splinting implants together or reducing the occlusal forces acting on them.

Implant splinting

Implant splinting serves two ends:

1. It reduces the force delivered to each implant in proportion to the total number of implants.
2. It neutralizes the three types of rotational moments.

For single crowns

An implant that supports a single crown is subject to all possible types of moments around the long axis of the implant, the mesiodistal axis, and the buccolingual axis (see Fig 4-10a). The mesiodistal moments can be minimized by designing the crown so that it has tight contact points with the adjacent teeth.

For fixed partial dentures supported by two implants

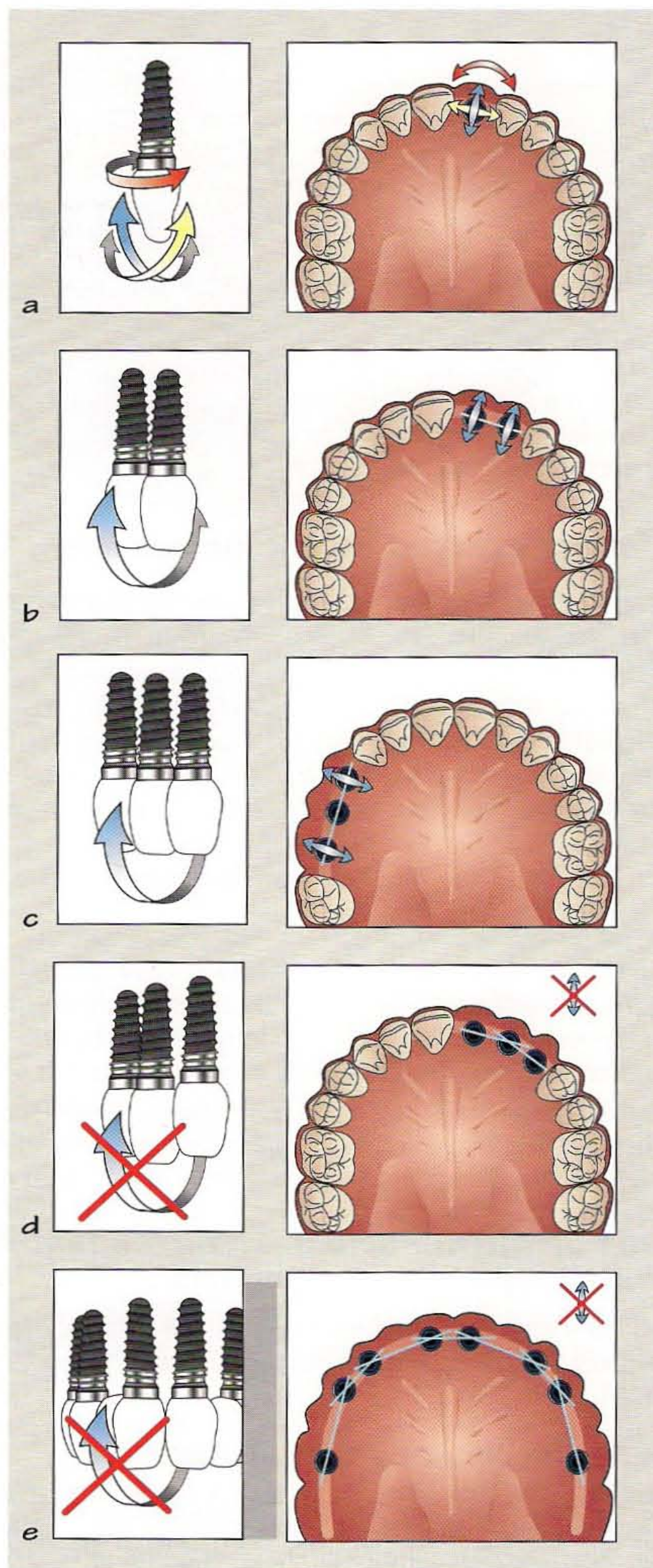
When a fixed partial denture is supported by two implants, the axial moments and the mesiodistal moments are both neutralized. The buccolingual moments persist, however, and can cause lateral micromovement (Fig 4-10b).

For fixed partial dentures supported by three implants

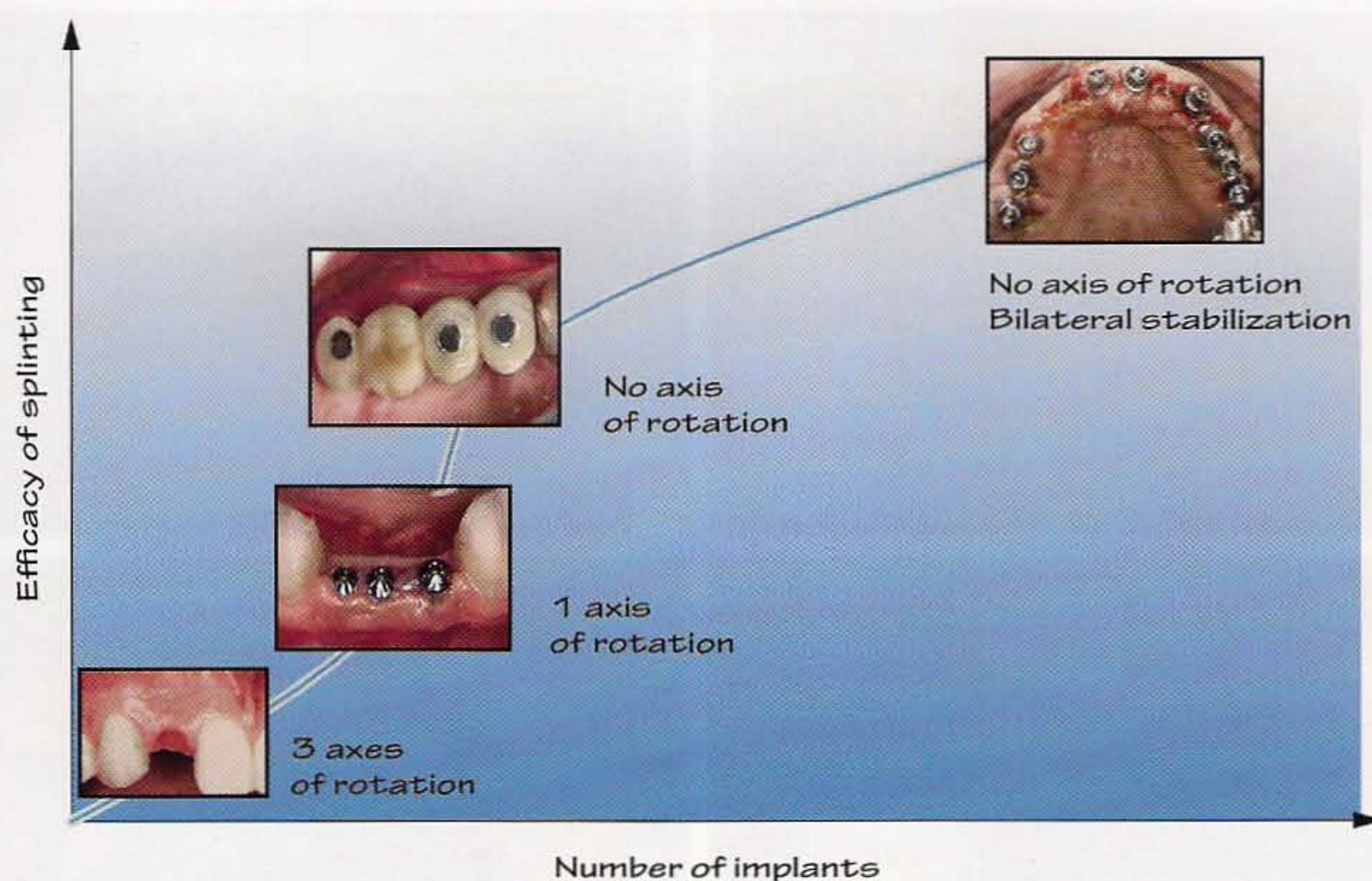
Fixed partial dentures can be supported by three implants aligned either along a single plane (Fig 4-10c) or on different planes (Fig 4-10d). In the first instance, moments directed along the buccolingual axis persist. However, when the three implants are set far enough apart to achieve a tripod effect, the difference in their planes of insertion neutralizes all buccolingual moments (see Fig 4-10d).

For prostheses in an edentulous arch

In an edentulous mandible arch, five or six implants should be distributed along at least three different axes. The same applies in the maxilla, where more implants are inserted (Fig 4-10e). This neutralizes all rotational moments on the individual axes. This factor becomes more important when the implants are subjected to a full occlusal load. Figure 4-11 shows how to obtain maximum benefit from implant splinting in relation to the number of implants.



▲ **Fig 4-10** Rotational moments (arrows) according to the type of restoration. (a) Single implant. (b) Two-unit prosthesis. (c) Three-unit prosthesis supported by three implants aligned on the same plane. (d) Three-unit prosthesis supported by three implants aligned on different planes. (e) Complete denture.



▲ **Fig 4-11** Influence of the number of implants on the efficacy of splinting. Neutralization of mesio-distal and buccolingual axes of rotation increases the efficacy of splinting. (Prosthesis by Dr M. Bischof and Dr R. Nedin.)

Metallic reinforcement

Implants are splinted together by bonding to the acrylic resin of the prostheses. Some authors suggest that the prosthesis be reinforced with a metallic element. This addition is less often indicated for two- or three-unit fixed partial dentures than it is for complete-arch prostheses.

In particular, metallic reinforcement is rarely employed in reconstruction of the edentulous mandible. For these cases, the solidifying acrylic resin bulk of the prosthesis is usually sufficient. Furthermore, stress is usually directed at the long axes of the artificial teeth, and the supporting implants are usually placed in bone of good quality.

Metallic reinforcement is more frequently required for maxillary complete dentures, because they include less acrylic resin bulk than do mandibular prostheses. Maxillary stress is exerted in a centrifugal direction, exerting shear stress on the prosthesis. In addition, maxillary bone is less dense than mandibular bone. In the clinical experience of the authors, all failures observed in the edentulous maxilla have been related to fracture of a nonreinforced acrylic resin prosthesis. Therefore, metal reinforcement of all maxillary implant-supported provisional prostheses is strongly advocated.

Another factor that affects the strength of the maxillary prosthesis is the inclusion of embrasures between crowns to encourage the growth of papillae. Because the embrasures must be continuous from the buccal side to the palatal side of the prosthesis, they unavoidably weaken it. Laboratory technicians may be inclined to minimize embrasure size in an effort to strengthen the prosthesis, but the clinician wants sufficient space left for papillary growth. The solution is, for both complete and partial prostheses, metal reinforcement to allow room for generous embrasure size and papillary expression without weakening the prosthesis.

The construction of this metallic reinforcement has been previously described.³¹ Briefly, a line is inscribed with a marking pencil along the cingula of the incisor and canine denture teeth; the line is continued across the vertical midline of the premolars and molars (Figs 4-12a and 4-12b). The resin in the area of this mark is removed (Fig 4-12c), and the preparation is filled with wax (Fig 4-12d). The prepared wax model is then cast to form the metal bar (Fig 4-12e), which is placed in the prosthesis and stabilized with resin (Fig 4-12f).



▲ **Fig 4-12** Reinforcement of a complete denture. (a) Acrylic resin prosthesis before placement of a metal bar. (b) Markings indicating the site for the bar. (c) Prosthesis prepared to receive a bar at the cingula of the anterior teeth and midway along the palatal surfaces of the premolars and molars. (d) Prepared area filled with wax. (e) Metal bar after casting. (f) Metal bar secured in the prosthesis.

With this kind of reinforcement, the technician can safely enlarge the embrasures in the prosthesis without fear of weakening it. The metallic bar serves the additional function of providing a bite-step for the anterior teeth. The mandibular anterior teeth occlude against the bar, not the acrylic resin, prolonging the life of the provisional prosthesis by reducing wear.

Management of occlusal contacts

The severity of the mechanical stress to which an immediately loaded prosthesis is subjected depends on whether it is in or out of occlusion (immediate occlusal loading versus immediate nonocclusal loading). To ensure that the prosthesis is not in occlusion, occlusal contact is avoided by 0.2 to 2.0 mm. All lateral and protrusive movements and maximal occlusal closure are checked. The type of occlusion appropriate to various types of prostheses is reviewed in Table 4-1.

TABLE 4-1 Classification of occlusal contact according to the type and location of the prosthesis

	Completely edentulous		Partially edentulous			
	Mandible	Maxilla	Anterior mandible	Single maxillary anterior crown	Anterior maxilla	Posterior mandible or maxilla
Occlusal Contact	Yes	Yes	No	No	No	No

Crown replacing a single tooth

Single crowns are always kept out of occlusion by as much as 2 mm.

Two- and three-unit anterior fixed partial dentures

Two- and three- unit anterior fixed partial dentures are also kept out of occlusion by as much as 2 mm.

Two- and three-unit posterior fixed partial dentures

In the posterior area, occlusal forces are high and bone is often softer than in the anterior region. Therefore, it is crucial to carefully keep all types of short-span prostheses out of occlusion. This is easily accomplished when the prosthesis is placed between natural teeth but more difficult when the edentulous site involves a distal extension.

Crown replacing a single posterior tooth

Single posterior crowns are also kept out of occlusion for the reasons previously mentioned. When a crown is placed between two teeth, however, the contacts of the restoration tend to spare it from mesiodistal rotational moments.

Complete prostheses

For functional reasons, complete prostheses cannot be kept out of occlusion. The occlusal stress generated can be overcome by increasing the number of splinted implants.

Anatomy of occlusal surfaces

When a complete arch is restored with an implant-borne prosthesis, full occlusal immediate loading cannot be avoided. There are two ways to treat these patients:

1. Preparation of a provisional prosthesis immediately after implant placement and later a final prosthesis after osseointegration is completed
2. Immediate preparation of a final prosthesis with a metal framework

For the provisional prosthesis, the occlusal surfaces can readily be adjusted to reduce the mechanical stress transmitted to the implants. The prosthodontist should:

- Strive for group function. The occlusal surfaces should be flattened to allow the prosthesis to slide easily in all lateral and protrusive movements.
- Limit the size of the occlusal surfaces. This will minimize the forces transmitted to the provisional prosthesis. The presence of a metal bar will facilitate this action because, when buccolingual dimensions are reduced, a prosthesis fabricated completely of acrylic resin resists stress more poorly.

When a final restoration is placed immediately, management of occlusal surfaces is more critical. It is then possible to:

- Reduce the size of the occlusal surfaces as far the requirements of a working prosthesis will allow. In practice, it seems that a 30% decrease in surface area cuts lateral forces by 48%.³²
- Request that the patient wear a nightguard and, eventually, continue wearing it during part of the day.
- Initially provide the denture with provisionally reshaped, flattened, commercially available teeth and later install new teeth with sharp, well-defined cusps better adapted for mastication.

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Chapter 5

THREE-DIMENSIONAL PLACEMENT OF IMPLANTS

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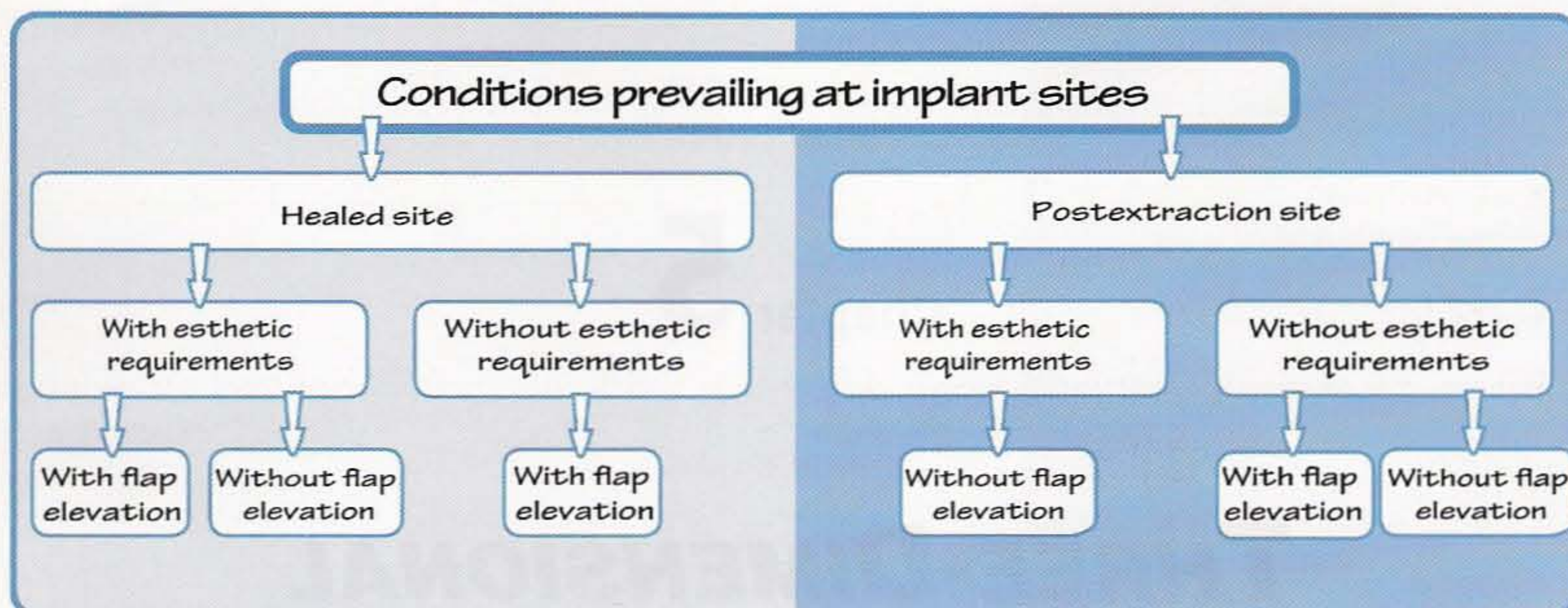
The correct placement of implants in all three dimensions must primarily be in harmony with the prosthetic requirements of the planned restoration. However, the shape and nature of the hard and soft tissues of the site and their anticipated reaction to implantation will also affect the three-dimensional (3D) positioning. The scope of possible circumstances for implant placement is outlined in Fig 5-1. Implants can be placed in either a healed site (Fig 5-2a) or a postextraction site (Fig 5-2b). For each of these locations, there are two possibilities:

1. The restoration has to conform to specific esthetic requirements related to the position of the papillae and gingival contour, as is the case when missing maxillary anterior teeth are replaced (see Figs 5-2a and 5-2b).
2. The restoration does not have to address soft tissue esthetics at all, as is the case when a completely edentulous mandible is restored (Figs 5-2c and 5-2d).

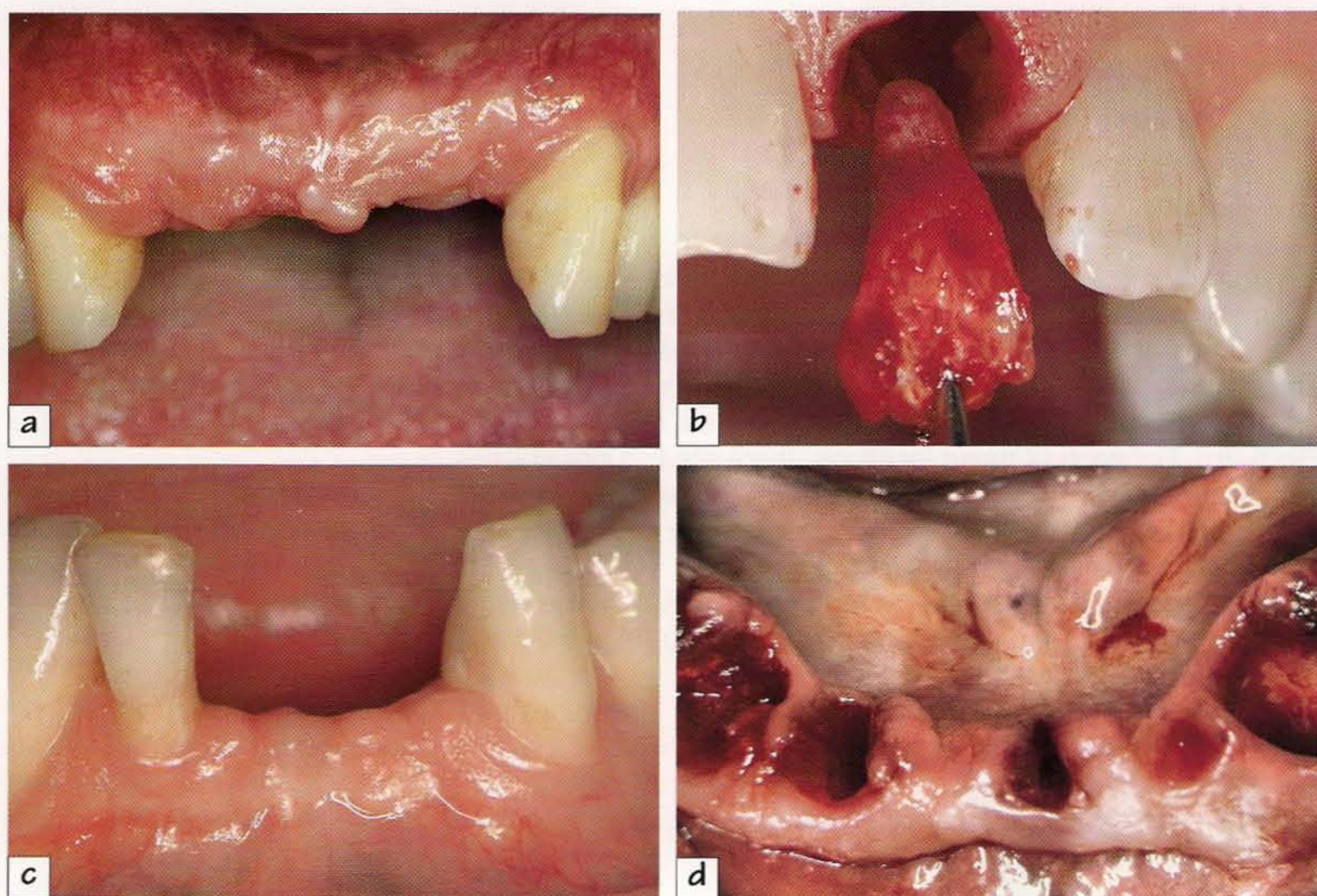
Implant placement should be prosthetically driven instead of surgically driven. Prosthetic considerations relate to biomechanical requirements of stress distribution as well as to esthetic concerns. When esthetic requirements are critical, precise 3D implant placement is paramount. However, when soft tissue esthetic considerations do not prevail, the surgeon has more flexibility in implant positioning.

▼ **General Rules for Implant Placement**

The 3D implant positioning must consider the following three planes: (1) mesiodistal, (2) bucco-lingual (or buccopalatal), and (3) coronoapical. These planes define the emergence site of the implant in the dental arch and the implant angulation. Implant positioning in all three planes must conform with the biologic rules described in the following sections.



▲ **Fig 5-1** Possible prevailing tissue conditions at implant sites. Sites can be healed or fresh extraction sockets, with or without special esthetic requirements with respect to papillae and gingival contour. Access to bone may be obtained with or without flap elevation. In healed sites, a gingival punch can be used to access bone without raising a flap. In postextraction sites, access to the alveolus is immediately available and no flap elevation is needed.



▲ **Fig 5-2** Examples of possible circumstances at implant placement. (a) Healed sites with esthetic requirements. (b) Postextraction sites with esthetic requirements. (c) Healed sites without esthetic requirements. (d) Postextraction sites without esthetic requirements.

Principles of peri-implant tissue healing

Clinicians must understand and be guided by the principles that govern the biologic reaction of hard and soft tissues to implant placement and function. The aim is to maintain the bone level present at implant placement and to preserve the esthetic conditions of the surrounding soft tissue over the long term.

Preservation of the biologic width

Teeth are the only organs simultaneously rooted in a sterile environment and protruding into a teeming septic external milieu. These two realms are separated by a tissue junction composed of a group of structures that defines a *biologic width*. The biologic width of a tooth encompasses the tissues from the top of the gingiva to the most apical point of the connective tissue in contact with bone, and it consists of three levels:

1. Gingivobuccal groove, or sulcus
2. Epithelial attachment or junctional epithelium
3. Mucosal attachment

The natural soft tissue structure that separates the internal and external milieus of a tooth develops in a similar way around an implant. The difference is that the biologic space around a natural tooth develops progressively as the tooth erupts in harmony with other surrounding periodontal tissues, while the biologic space around an implant derives from a reorganization of preexisting tissues (Fig 5-3).

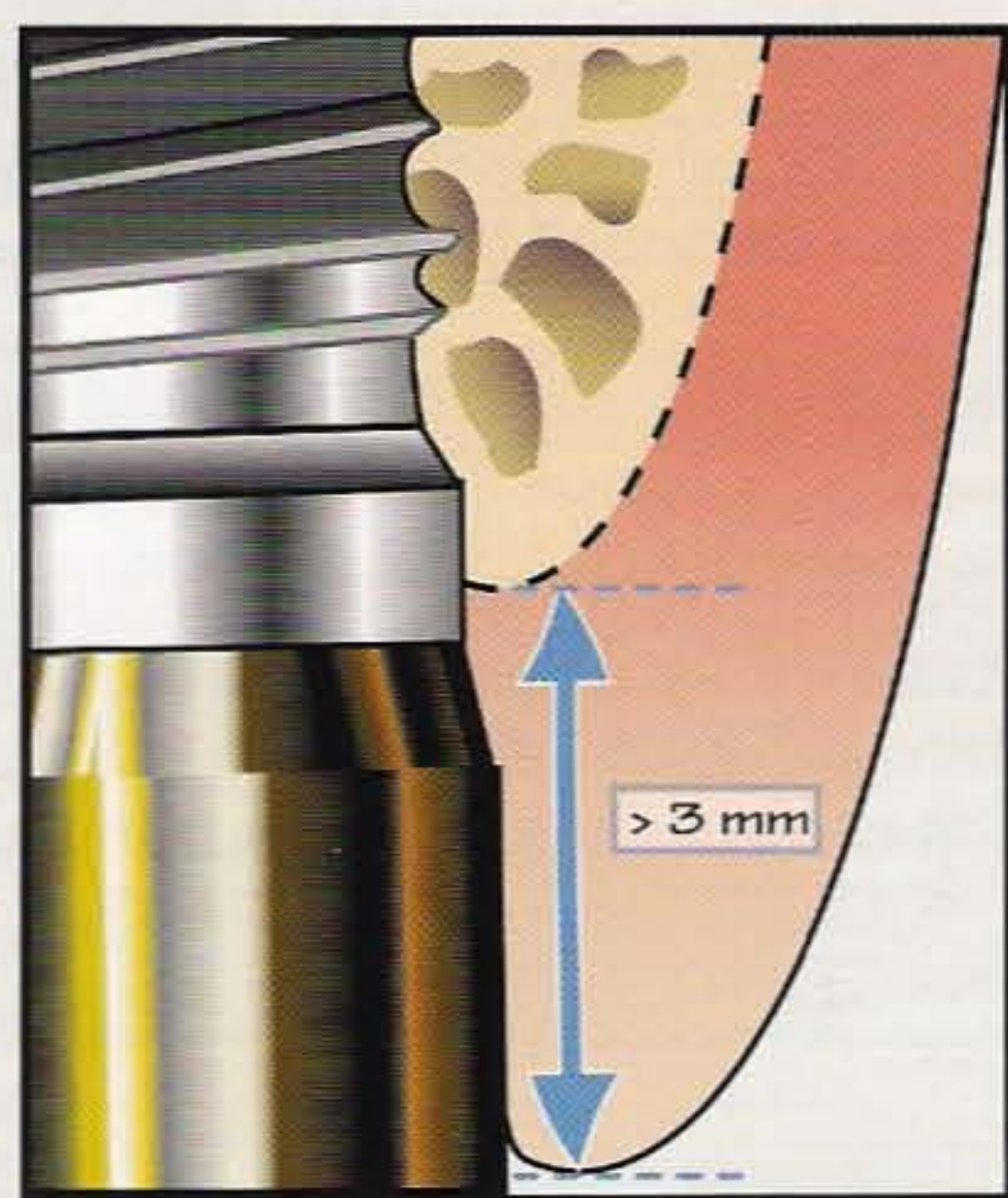
The gingival seal around an implant consists of a sulcus approximately 1 mm in depth, an epithelial junction of 1 to 2 mm, and a mucosal attachment of 1 to 2 mm. This assembly, at least 3 mm thick (see Fig 5-3b), forms the so-called biologic width and is a biologic constant.¹ No matter when and how the implant is loaded, this measurement varies very little over time.² If, for any reason, the thickness of this biologic barrier drops below 3 mm, it reorganizes itself to regain its initial dimensions (see Fig 5-3d).³

The implant assembly consists of three elements: the implant itself, the abutment, and the crown. The junctions between these elements are the implant-abutment junction and the crown-abutment junction. This complex structure generates both mechanical and bacterial insults to the biologic seal formed around the implant (Fig 5-4). According to various hypotheses proposed in the literature, chronic insults can result in the presence of microgaps at the implant-abutment junction,^{4,5} bacterial infiltration along the implant-abutment junction,⁶⁻⁸ micromovement at the implant-abutment junction,⁹ or mechanical stress caused by occlusal function.¹⁰ Transitory insults, arising from prosthetic manipulation (screwing and unscrewing of the abutment), also have been identified.¹¹

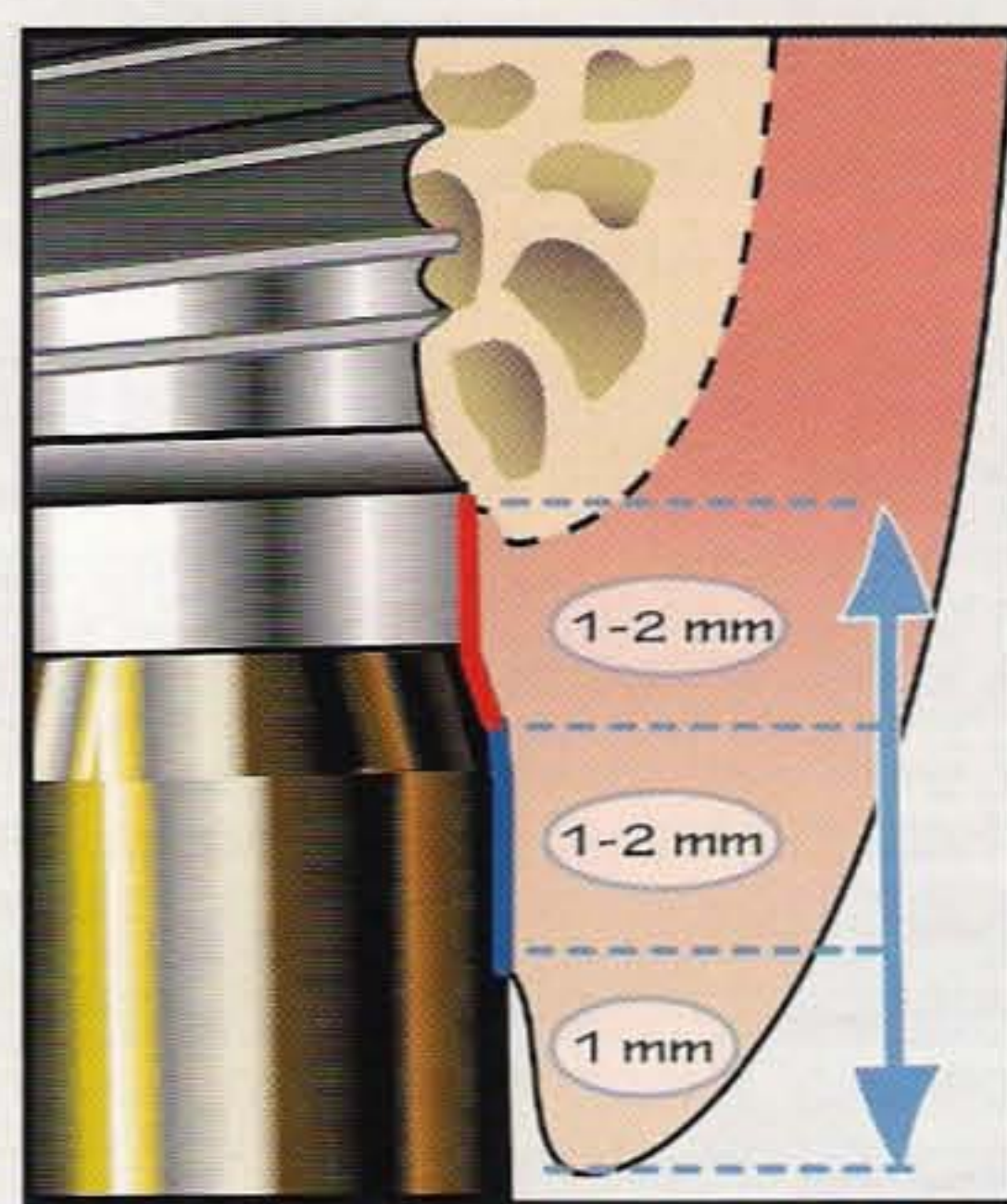
The organism protects itself against attacks, whether bacterial or mechanical in origin, by keeping the affected bone at a defined distance from the insult. The biologic seal then reorganizes itself in accordance with the respective dimensions of the three components, that is, according to the rule of preservation of the biologic width. Thus, the coronal level of the bone-implant contact retreats apically through bone resorption to reestablish the minimum 3-mm biologic width (see Fig 5-3d).¹²

Similarly, repeated insults at the epithelial attachment cause it to re-form more apically (Fig 5-5). The most coronal bone-implant contact resorbs apically to preserve the biologic width (see Fig 5-5b). Thus, with implants placed in a two-stage procedure, the repeated unscrewing of healing abutments stimulates the epithelial junction to migrate down to the implant neck. This epithelial migration induces bone resorption and leads to formation of a bone crater around the implant-abutment junction (see Figs 5-3d and 5-5b). Some authors assert this reason to explain the resorption of bone that reaches the first thread during the first months of function.¹¹

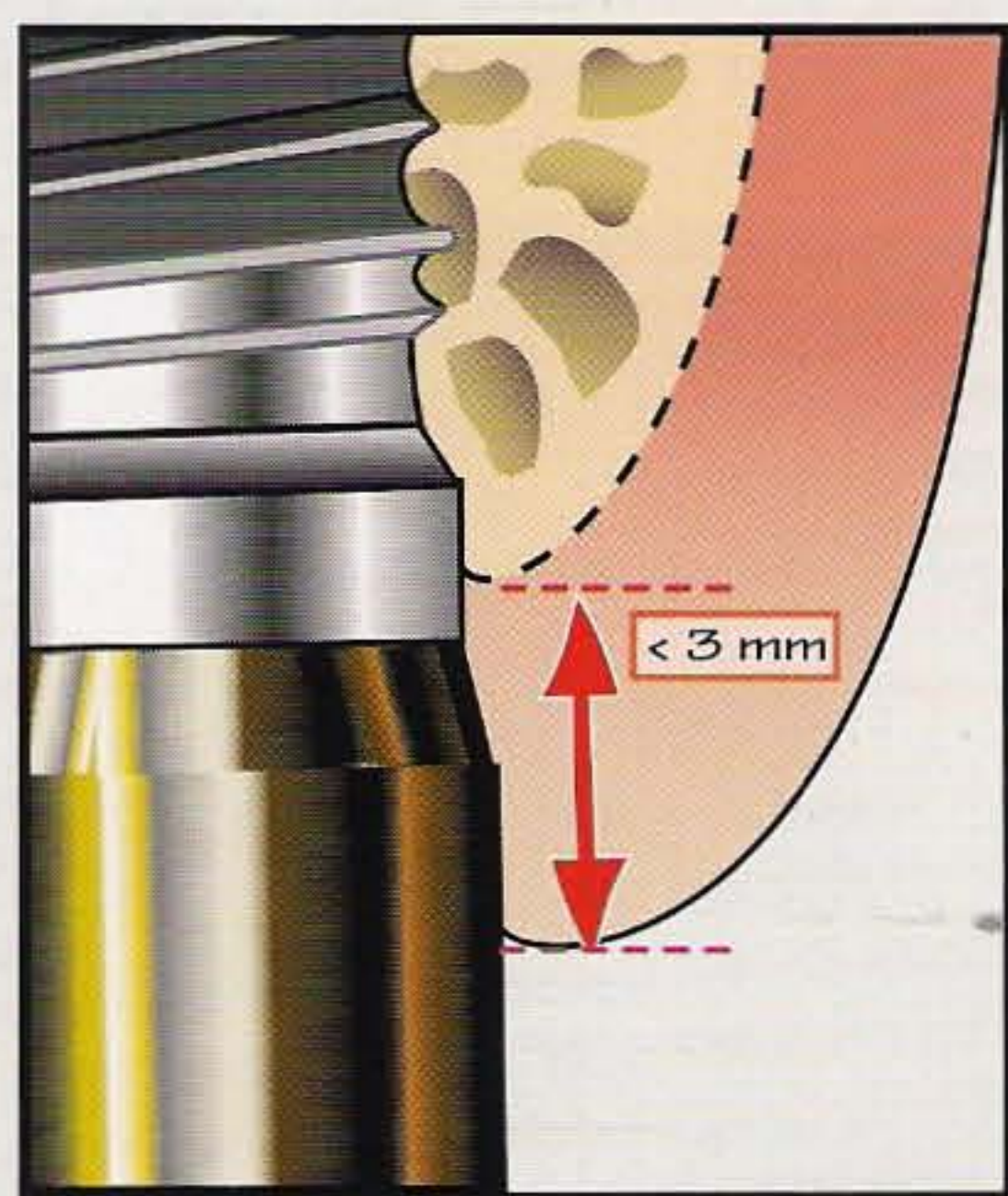
Where the buccal cortical plate is less than 2.0 mm thick (see Fig 5-5c), resorption of the underlying bone in an apical direction affects the full thickness of the cortical plate¹³ and causes gingival recession of as much as 1.5 mm.¹¹ To prevent this from happening, a distance of at least 2.0 mm should be maintained between the external edge of the implant and the edge of the buccal cortical plate. When this distance cannot be obtained, unscrewing of the abutment of the provisional prosthesis should be avoided.



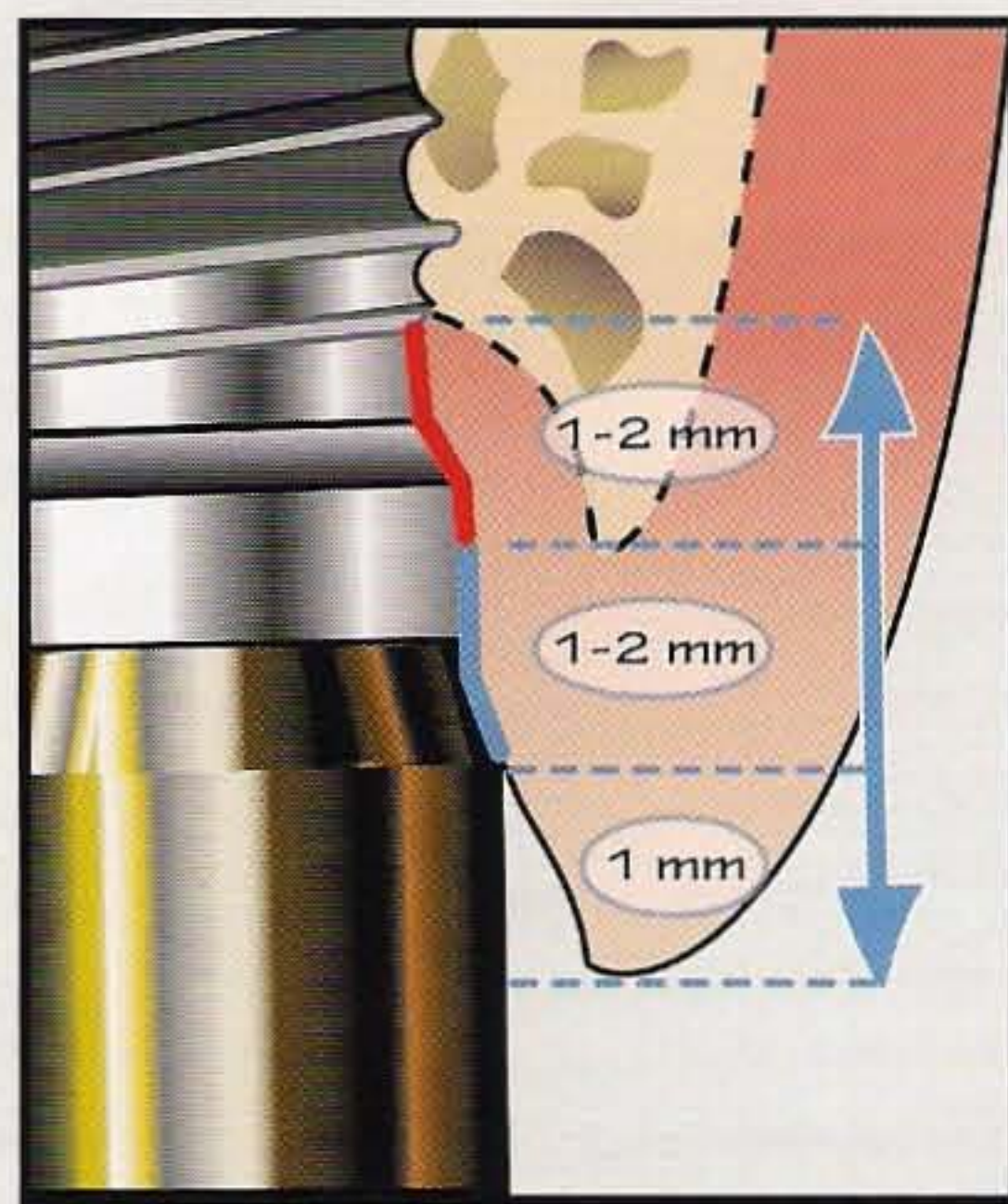
a



b



c



d

▲ **Fig 5-3** Principles of preservation of the biologic width. (a) Relationship of the implant to hard and soft tissues at the time of implant placement when the soft tissue is greater than 3 mm thick. Immediately after surgery, the soft tissues are in close contact with the healing abutment; note the relationship between the bone crest and the implant neck. (b) Preservation of the biologic width when the soft tissue is more than 3 mm thick. The sulcus, the epithelial attachment, and the mucosal attachment are located within this 3-mm depth. The bone has migrated slightly apically in reaction to the trauma of surgery. (c) Relationship of the implant to hard and soft tissues at the time of implant placement when the soft tissue has been surgically reduced to less than 3 mm. Immediately after surgery, the soft tissues are in close contact with the healing abutment; note the relationship between the bone crest and the implant neck. (d) Preservation of the biologic width when the soft tissue thickness is less than 3 mm. The sulcus, the epithelial attachment, and the mucosal attachment have to reestablish a biologic width of 3 mm above the level of the crestal bone. For this to occur, the bone resorbs apically, to the level of the first thread. This forms a crater-shaped area of bone loss. The level of the bone crest is therefore dictated by the trauma of surgery and by the necessity to reestablish a mucoepithelial seal that takes into account the biologic width.

Chronic and transitory insults

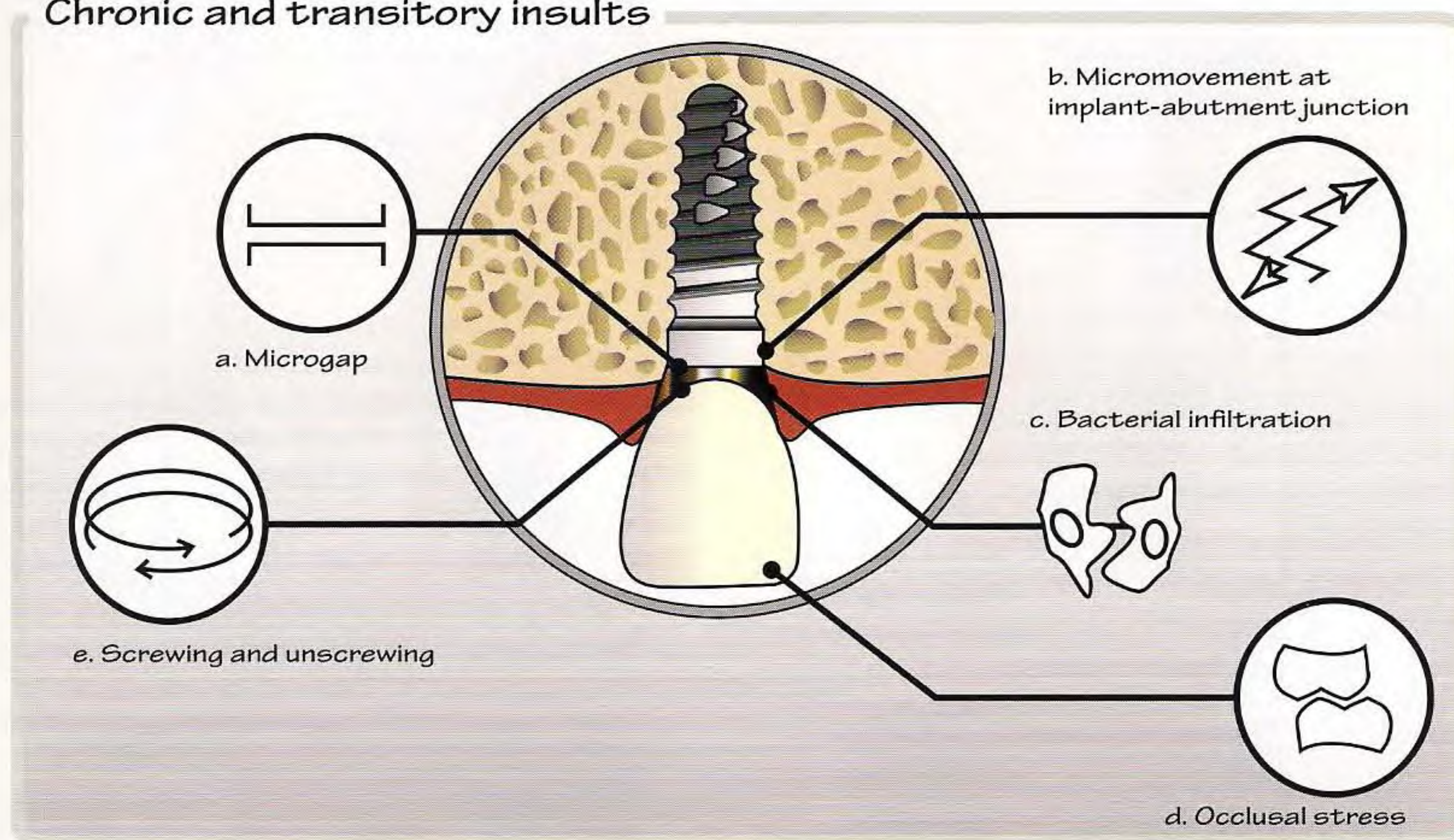


Fig 5-4 Chronic and transitory insults at the implant-abutment junction. (a) Microgap between the abutment and the implant neck. (b) Micromovement between the abutment and the implant neck. (c) Bacterial infiltration at the implant-abutment junction. (d) Occlusal stress. (e) Transitory insults from repeated manipulation of the healing abutment.

Distance between implants and adjacent structures

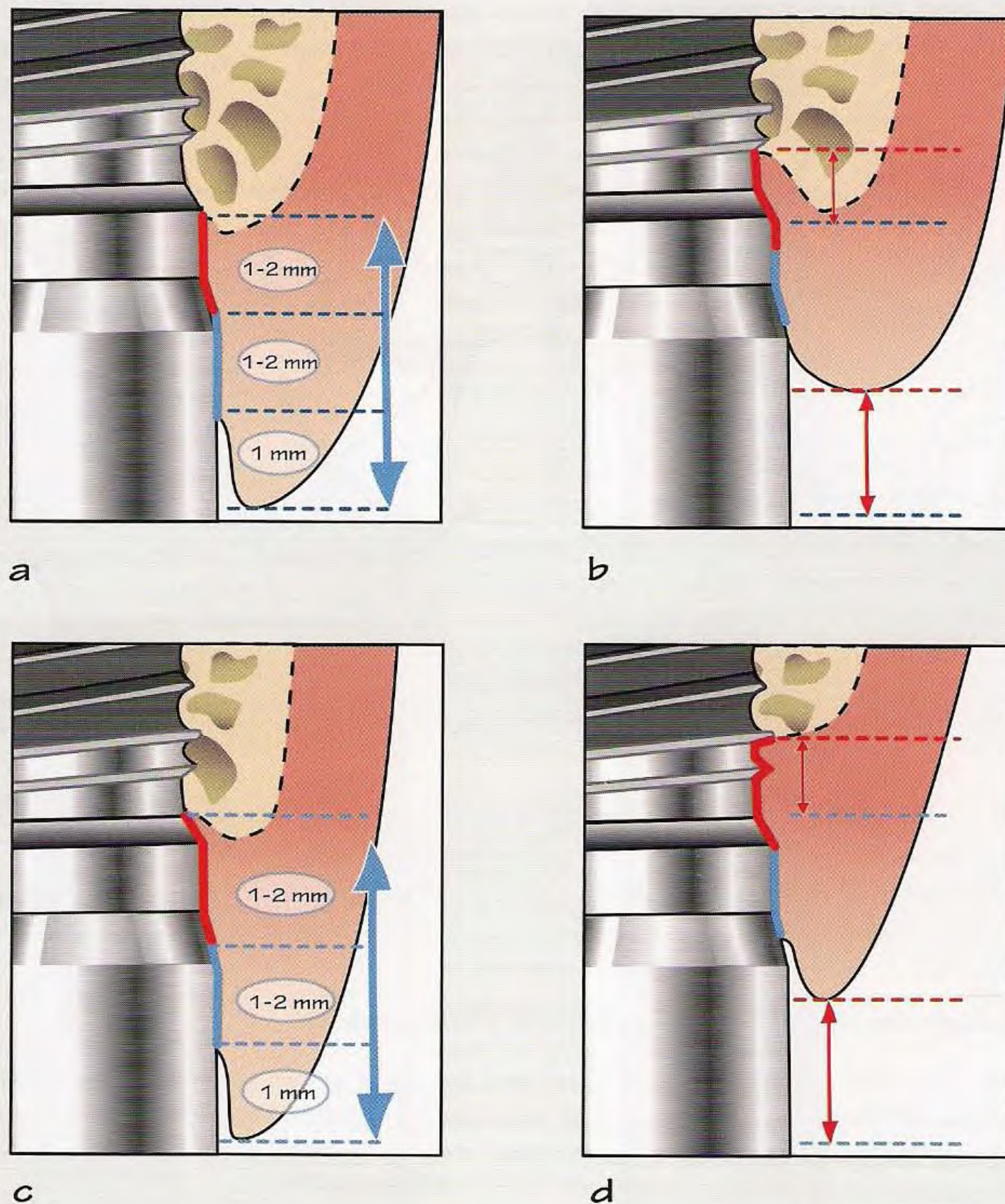
The principle of a minimal distance between two adjacent units, whether teeth or implants,^{13,14} derives from the principle of preservation of the biologic width in the mesiodistal plane. Minimal distances of 3.0 mm between two implants and 1.5 mm between an implant and an adjacent natural tooth should be maintained (Fig 5-6). These values are based on the bone resorption that occurs during the first months of implant function in the vertical and horizontal directions (see Figs 5-6b and 5-6d). Both resorption patterns involve the surrounding bone to a distance of 1.0 to 1.5 mm (Fig 5-7).

Vertically, this bone loss translates to an apical migration of the peri-implant bone level. Laterally, it translates to a bone loss of equivalent distance between the two implants. When the distance between two implants is less than 3.0 mm (2×1.5 mm), the height of the bone crest is entirely resorbed¹⁴ and the papilla no longer receives adequate support (see Fig 5-6b). On the other hand, when the distance between two implants is greater than 3.0 mm, the interimplant bone crest is preserved. The papilla receives the bone support it needs, assuring long-term maintenance of good esthetics (see Fig 5-6d). This resorption probably derives from the chronic insults previously described, but the precise etiology is not yet determined.

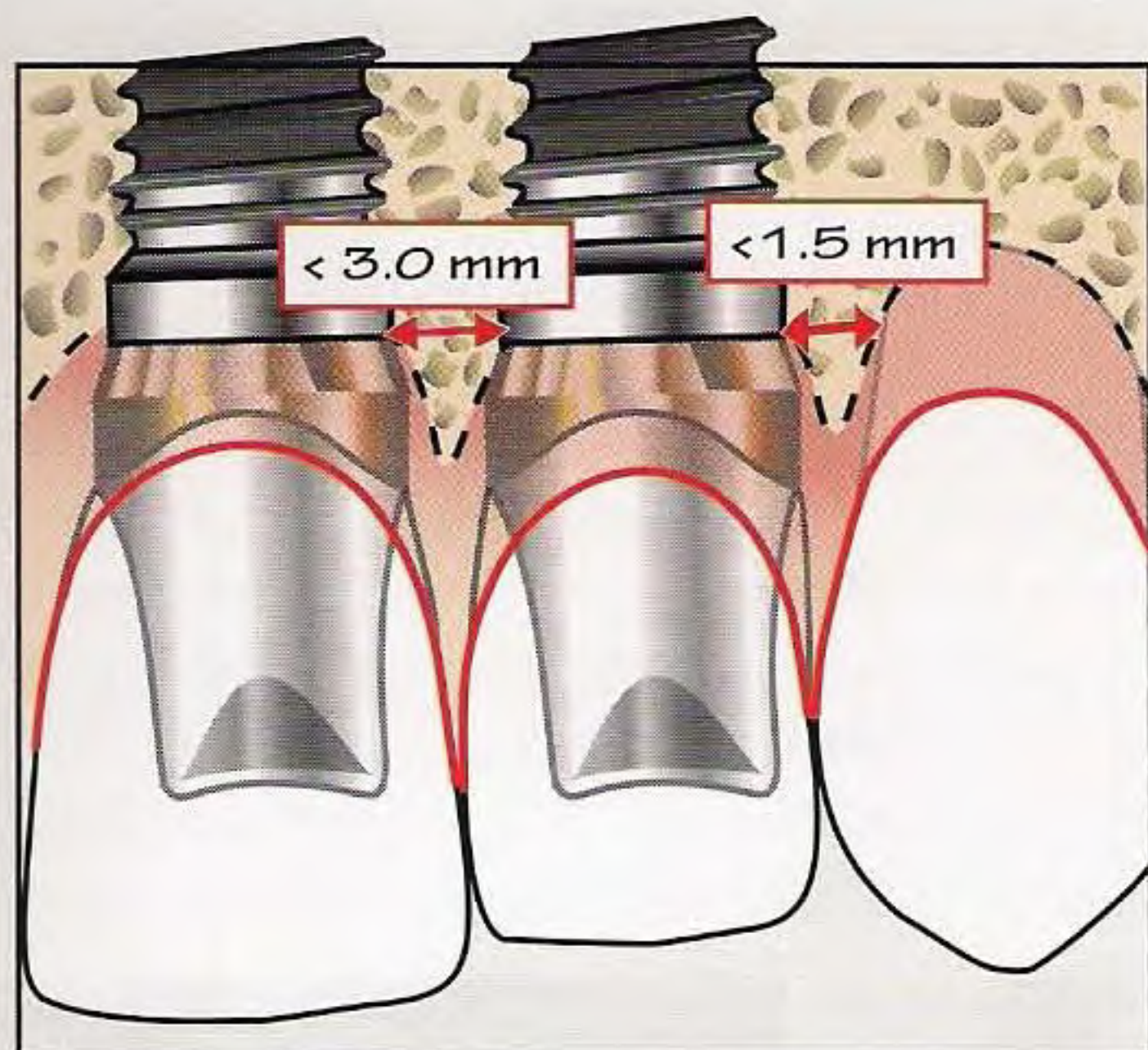
Bone resorption and roughness of the implant surface

Bone is a pressure-sensitive tissue that responds and adapts to stress. The changes in bone metabolism that astronauts experience as a result of the moon's microgravity demonstrate this property of osseous tissue. Bone responds in one of four different ways, depending on the intensity of stress to which the bone is subjected¹⁵:

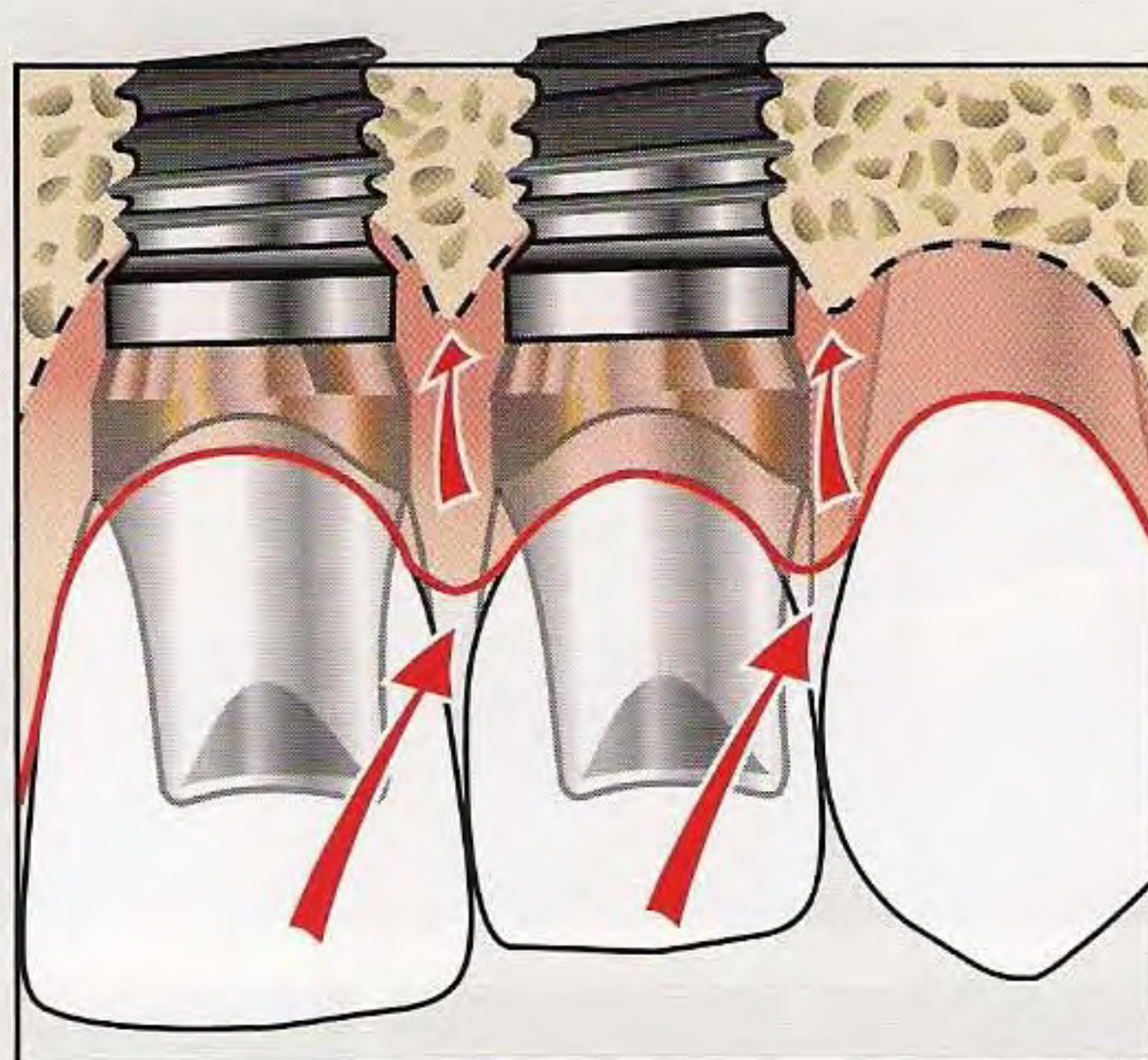
1. Atrophy accompanied by bone resorption when stresses are lower than physiologic levels ϵ ($< 100 \mu\epsilon$)
2. Balanced bone response when stresses are at a physiologic level (100 to 1,500 $\mu\epsilon$)



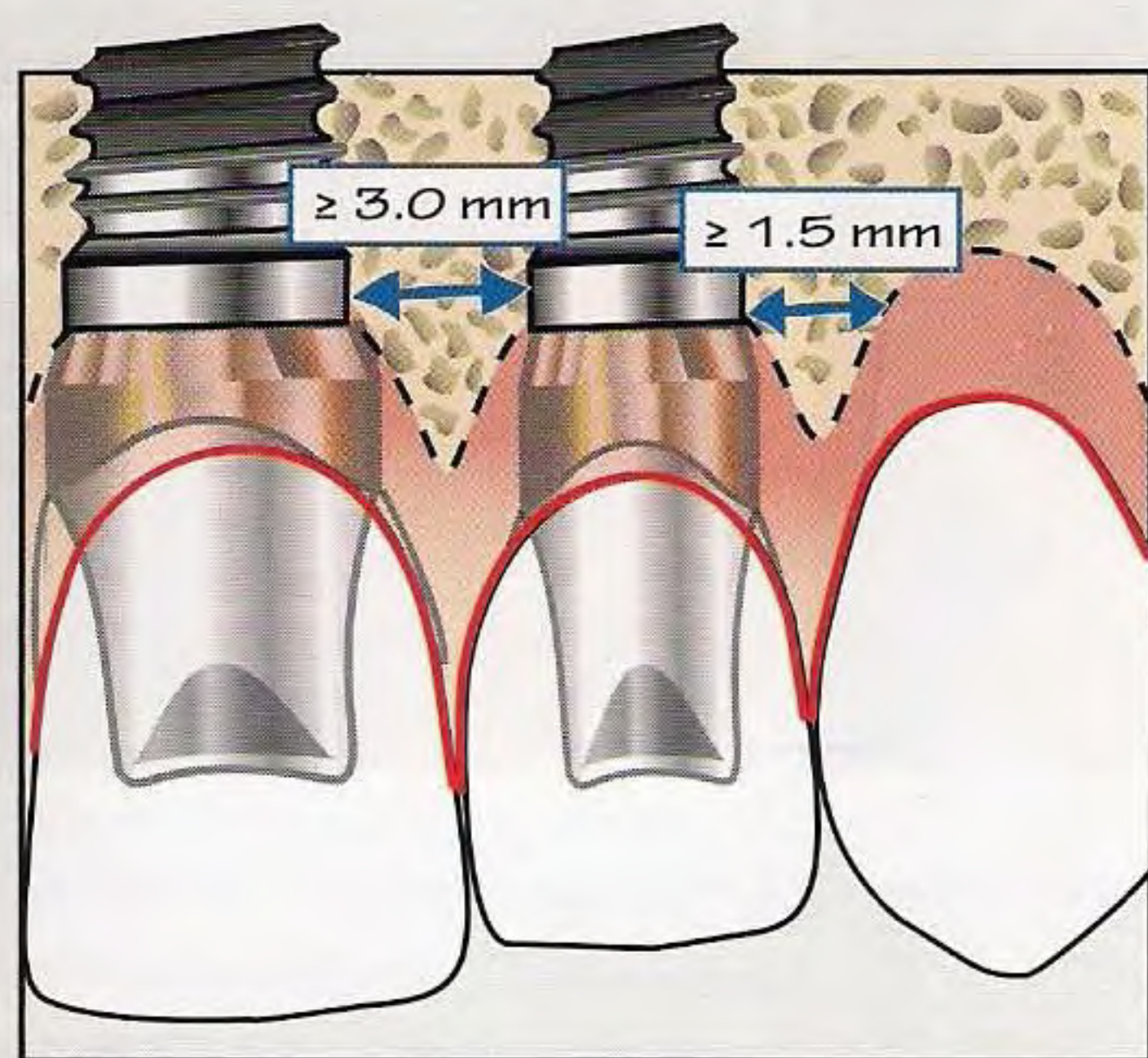
▲ **Fig 5-5** Apical migration of the junctional epithelium following repeated manipulation (screwing and unscrewing) of the healing abutment. (a) Relationship between the implant and the surrounding tissues when the abutment has not been unscrewed after placement and the buccal cortical plate is more than 2 mm thick. During healing, the biologic width establishes itself and the junctional epithelium attaches to the abutment. This maintains the initial bone-implant contact at a level coronal to the first thread. (b) Relationship between the implant and the surrounding tissues after repeated manipulation of the healing abutment and the buccal cortical plate is more than 2 mm thick. Screwing and unscrewing of the healing abutment has disrupted the junctional epithelium. This causes the epithelium–connective tissue junction to migrate toward the neck of the implant, impelling the initial bone-implant contact in an apical direction. (c) Relationship between the implant and the surrounding tissues when the healing abutment has not been unscrewed after placement and the buccal cortical plate is less than 2 mm thick. During healing, the biologic width has established itself and the junctional epithelium attaches to the abutment. This maintains the initial bone-implant contact at a level coronal to the first thread. (d) Relationship between the implant and the surrounding tissues after repeated manipulation of the healing abutment and the buccal cortical plate is less than 2 mm thick. Screwing and unscrewing of the healing abutment has disturbed the mucoepithelial attachment. It has migrated apically on the implant neck, impelling the bone crest in the same direction.¹¹ The bone loss does not exhibit a craterlike pattern; instead, the cortical plate is resorbed through its entire extent because of the limited thickness of the buccal plate. The cortical plate migrates apically, and the gingival recession is extensive.



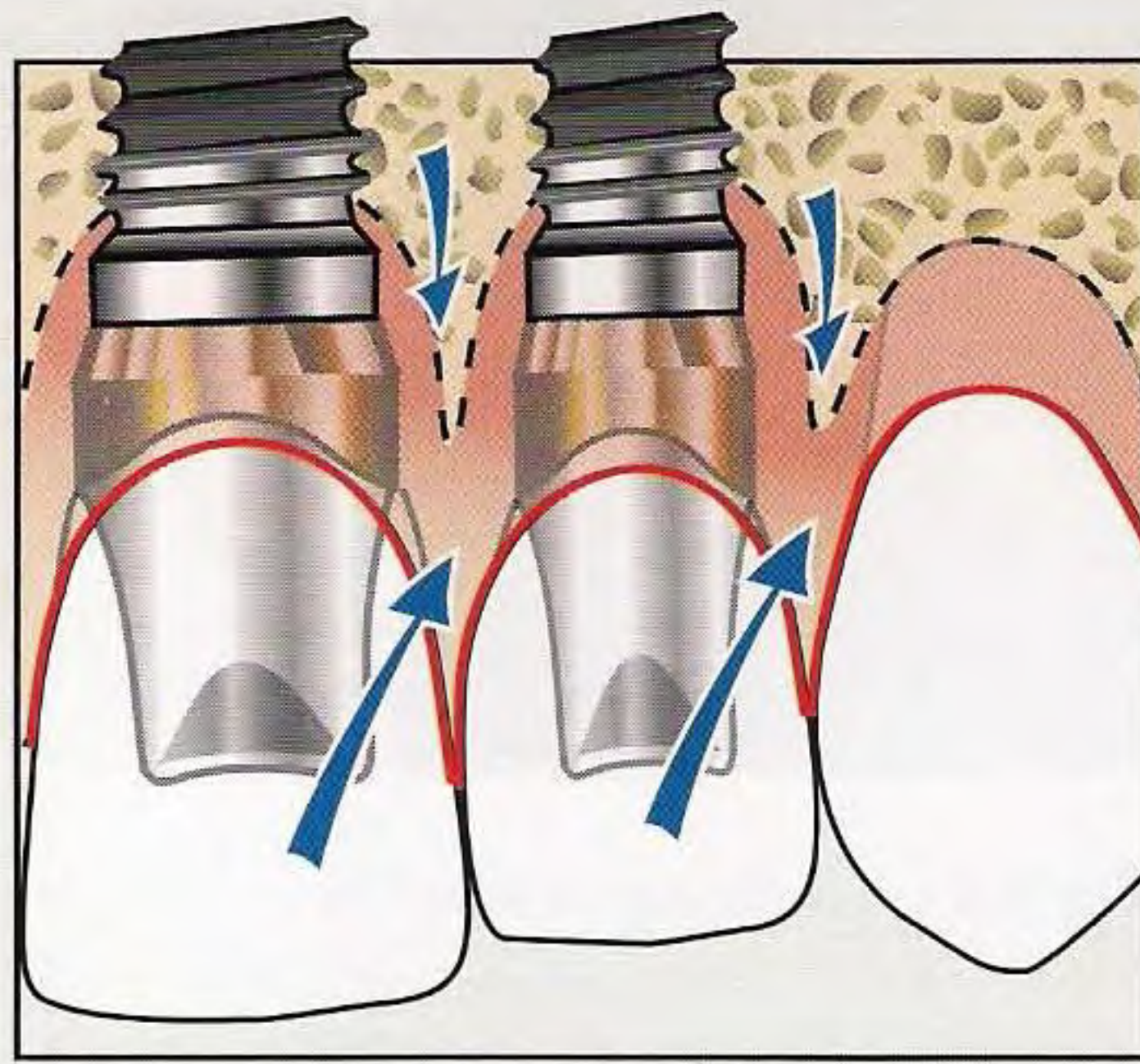
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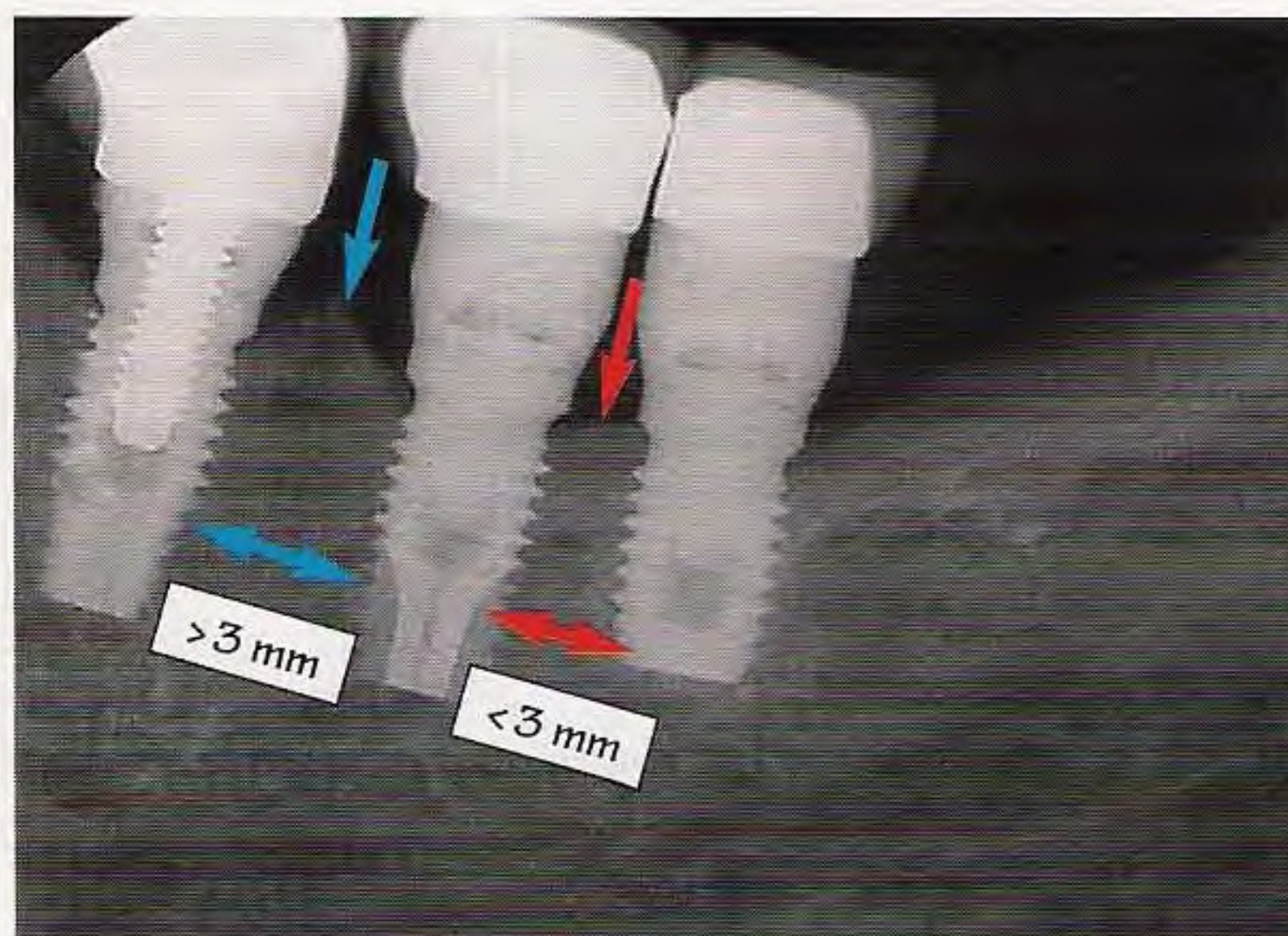
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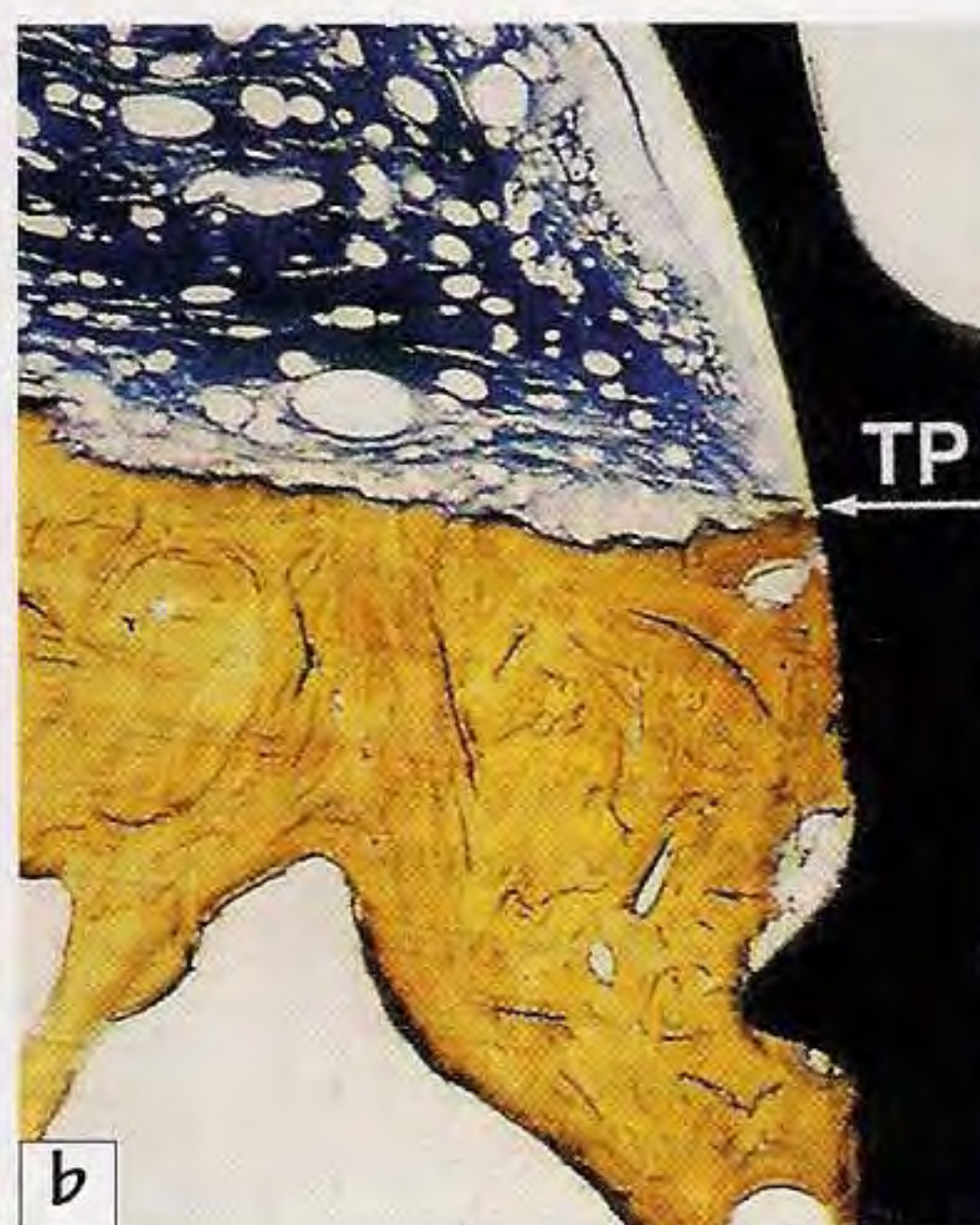
d

▲ Fig 5-6

Principle determining the minimal distance between two implants or between an implant and a tooth. (a and b) Response when the distance between two implants is less than 3.0 mm and the distance between tooth and implant is less than 1.5 mm. (a) At the time of implant placement, bone crests are present between implants and between implant and tooth. (b) After 6 months of function, the bone crests between the implants and between the implant and the natural tooth have disappeared (small red arrows), and gingival recession has followed (large red arrows). (c and d) Response when the distance between implants is greater than 3.0 mm and the distance between implant and tooth is greater than 1.5 mm. (c) At the time of implant placement, bone crests are present between implants and between implant and tooth. (d) After 6 months of function, the bone crests between implants and between implant and tooth have remained in place, although their sides have partially resorbed (small blue arrows). The bone crests provide satisfactory support for gingival papilla, which can thrive over time (large blue arrows).



▶ **Fig 5-7** Relationship between the interimplant distance and vertical and horizontal bone resorption. After 3 months of loading, vertical and horizontal resorption has occurred around the implants. Where the distance is greater than 3 mm, between the two implants on the left, the interimplant bone crest has persisted (*blue arrows*). Where the distance is less than 3 mm, between the two implants on the right, the bone crest has been lost (*red arrows*).



▶ **Fig 5-8** Relationship between bone reaction and implant surface. (a) One-stage implants with a titanium plasma-sprayed (TP) surface (*left*) or a machined surface (*right*). Both implants, with their different surfaces, were placed in the dog mandible at the same level. (b) Bone reaction to the implant with the roughened surface. The bone level has remained stable at the junction of the machined and roughened surfaces. (c) Bone reaction to the implant with the machined surface. The bone level did not stabilize at the bone crest; it has migrated apically to the first thread, where the first mechanical contact takes place. Compare this bone height with the level where TP surface would have ended, if this had been a roughened implant. (Reprinted with permission from Gotfredsen et al.¹⁸)

3. Hypertrophy when stresses are slightly greater than physiologic levels (1,500 to 4,000 $\mu\epsilon$)
4. Resorption when stresses are too high ($> 4,000 \mu\epsilon$)

Reminder:

The microstrain ($\mu\epsilon$) is a unit of stress describing the deformation of materials under pressure. It is expressed by $\Delta\ell/\ell$ the variation in length of $\Delta\ell$ after exposure to a stress, divided by the total length.

Machined titanium surfaces (Fig 5-8a), unlike roughened surfaces (Fig 5-8b), do not achieve micromechanical anchorage at the bone-implant interface (Fig 5-8c).¹⁶ Mechanical forces are thus not transmitted to the interface, and bone receives no mechanical stimulation.¹⁷ An atrophic reaction begins, and bone resorbs to the area where the first mechanical stimulation takes place (see Fig 5-8c).



▲ **Fig 5-9** Position of the implant neck in relation to the bone crest. (a) Supracrestal position. The implant neck is above the bone crest. (b) Crestal position. The implant neck is level with the bone crest. (c) Subcrestal position. The implant neck is below the bone crest.

When an implant is positioned subcrestally, the smooth neck comes in contact with bone and prevents development of microanchorage at the bone-implant interface. Bone responds by migrating apically, away from the initial implant contact, toward the place where the first mechanical stimulation occurs. This principle must be taken into account while implant seating in the coronoapical direction is determined, especially in sites where esthetics is a major concern.

Bone resorption and level of the implant-abutment interface

The extent to which bone resorbs around implants, as it typically does, is governed by a variety of factors, including the impact of the surgical trauma, the preservation of the biologic width, and the reaction of surrounding tissues to transitory and chronic insults.

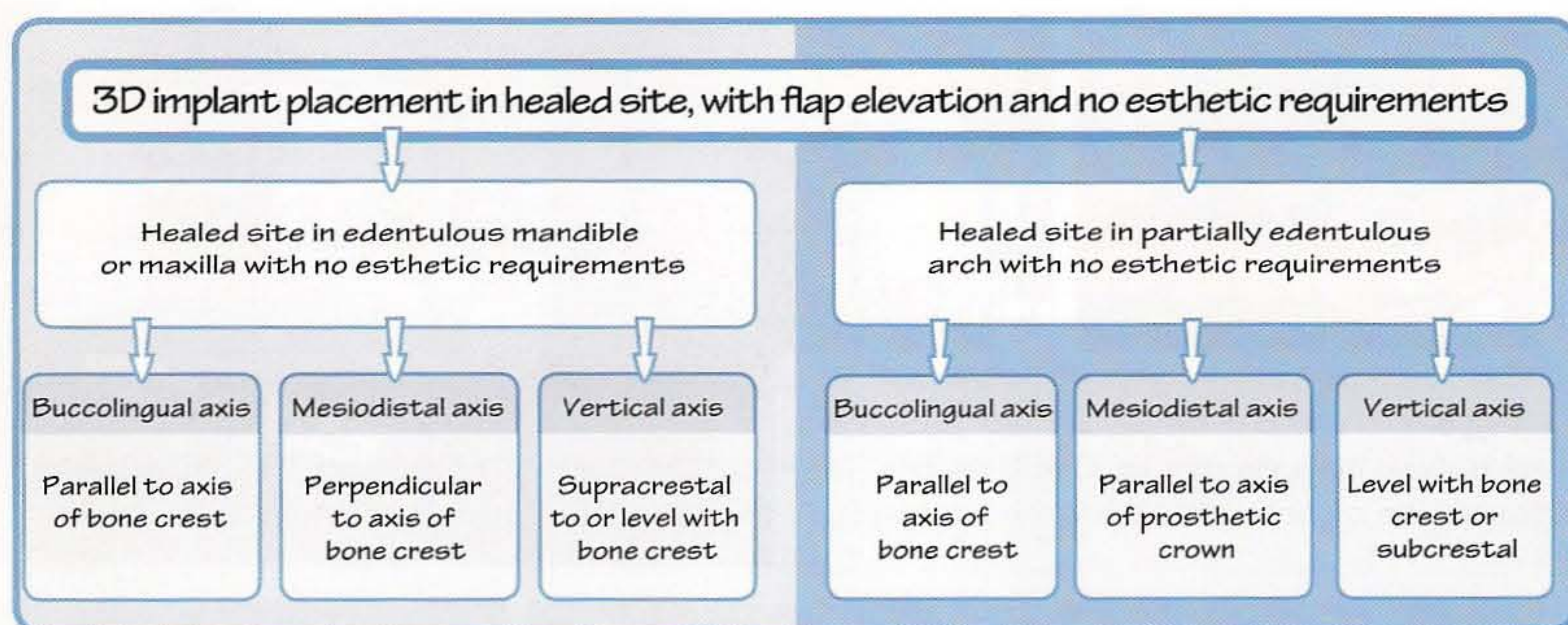
The coronoapical position of an implant is related to its design and should follow the recommendations of the manufacturer. However, appropriate adjustments must be made in response to the anatomic situation and to optimize ultimate esthetics. The coronoapical placement of an implant depends on where the implant neck is positioned in relation to the bone crest:

- Supracrestally (Fig 5-9a)
- At the level of the crest (Fig 5-9b)
- Subcrestally (Fig 5-9c)

The presence of the implant-abutment junction at the crest or at close proximity to it creates a zone of chronic insult in nearby bone. In accordance with the principle of preservation of the biologic width, this leads to vertical bone resorption in the coronoapical direction. However, the exact nature of the insult that leads to this bone loss is still unknown.¹⁹ Data derived from animal experimentation are often contradictory,^{12,20,21} meaning that the cause of this bone loss has not been adequately identified. However, research indicates that:

- When the implant-abutment junction lies at least 2.0 mm above the bone crest, no bone resorption occurs.^{12,20}
- When the implant-abutment junction is level with the bone crest, apical bone resorption of 1.0 to 1.5 mm occurs.^{12,20,21}
- The further the implant-abutment junction lies below the bone crest, the greater the resorption will be.^{22,23} However, the amount of apical bone resorption below the implant-abutment junction seems to be constant.
- Little data are as yet available concerning the extent of horizontal resorption that occurs in relation with deeper, subcrestal implant placement.²¹

If the buccal cortical plate is more than 2 mm thick, resorption will not remove the entire supporting plate; only craterization will result.¹³ If the cortical plate is thin, less than 2 mm thick, resorption will affect the plate over its entire thickness. This will cause gingival recession and esthetic complications (see Fig 5-23). Therefore, it is possible to anticipate the extent of bone resorption, depending on the position of the implant-abutment junction with relation to the bone crest.



▲ **Fig 5-10** 3D implant positioning in a healed site with no esthetic requirements. Mesiodistal and coronapical implant positioning in completely edentulous arches differs from positioning in partially edentulous arches. In edentulous arches, implant distribution follows the mechanical requirements; implants are placed so that their mesiodistal axes are perpendicular to the bone crest. In the coronapical axis, implants are positioned level with the crest or supracrestally; placement can even be subcrestal if it helps provide primary stability. In the partially edentulous arch, the mesiodistal axis conforms to the axis of the prosthetic crown to be supported. Implants are positioned level with the crest rather than supracrestally for prosthetic reasons, to allow a better emergence profile.

▼ 3D Implant Placement in Healed Sites

The presence or absence of esthetic requirements at the rehabilitated site plays a significant role in defining the criteria governing implant placement.

Placement outside the esthetic zone

Esthetics is not usually an important consideration when implants are placed in the posterior quadrants or in the edentulous mandible, especially when a screw-retained hybrid prosthesis ad modum Brånemark is planned. This can also be the case in the partially edentulous anterior maxilla for patients who have a low smile line.

In the edentulous mandible, esthetic considerations play a minor role; rather, mechanical requirements dictate implant distribution in the arch. Access to the ridge is gained through flap elevation, and 3D implant placement is facilitated because all the osseous landmarks are readily visible. Figure 5-10 summarizes the rules that govern determination of the various implant insertion axes.

Mesiodistal positioning

When the edentulous mandible or maxilla is rehabilitated with a hybrid prosthesis, the mesiodistal axes of the supporting implants can vary widely. However, the positioning must allow the withdrawal of an impression. The implant axis is generally perpendicular to the bone crest (Fig 5-11a). Sometimes, however, the most distal implants are placed with a distal angulation as great as 30 degrees.²⁴ This avoids implant placement in a region of reduced bone height, such as posterior to the foramen (Fig 5-11b), in a region of poor bone density, or in the maxillary sinus. In the mandible, such a strategy allows an increase in the anteroposterior distance and subsequently the length of extensions. However, this protocol is still insufficiently documented, so it cannot be recommended for routine application by inexperienced clinicians.



▲ **Fig 5-11** Mesiodistal implant positioning. (a) Implant placement in the edentulous mandible without esthetic requirements. The implant axis is perpendicular to the bone crest. (b) Angulated implant placement of the most distal implants in the edentulous mandible. (Courtesy of Dr T. Testori.) (c) Angulated placement dictated by the limited vertical dimension posterior to the foramen (same patient as in Fig 5-11b). (Courtesy of Dr T. Testori.) (d) Mesiodistal implant positioning in a partially edentulous arch. The axes of the implants conform to the prosthetic crowns they will support.



▲ **Fig 5-12** Buccolingual implant positioning. (a) Edentulous mandible. (b) Edentulous maxilla. The buccolingual axis of anterior implants is inclined too far buccally. (c) Implants that are angled too extensively. The screw access path emerges at the incisal edge or on the labial side of the crowns (arrows).

In instances where a single tooth or a short-span fixed partial denture needs replacement, the axis of the implant should be parallel to the axis of the crown being replaced (Fig 5-11c). Usually, this axis conforms to the axes of the adjacent teeth (Fig 5-11d).

Buccolingual positioning

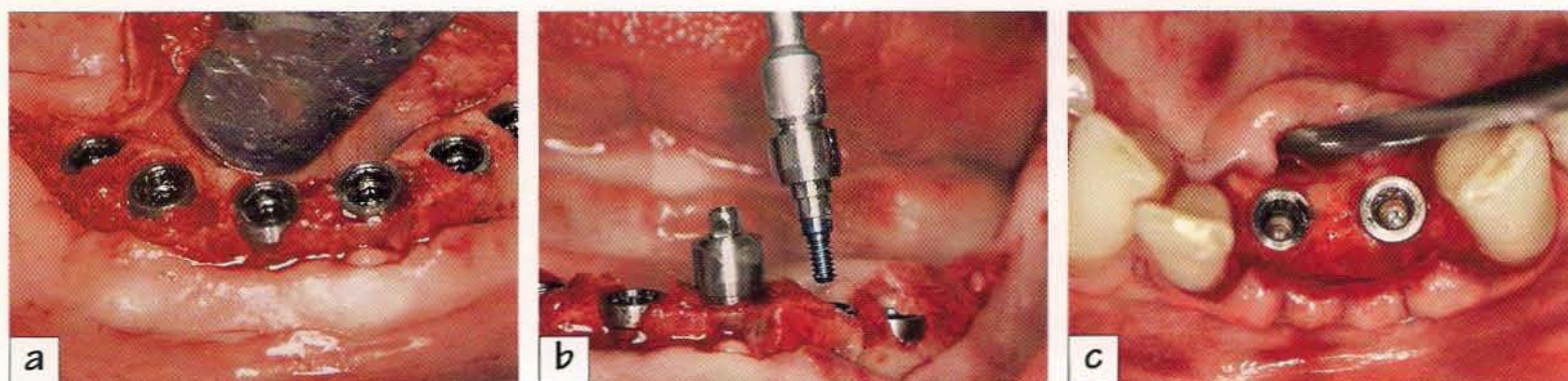
In the completely edentulous arch, the buccolingual axis is generally parallel to the bone crest (Fig 5-12a). Any angulation departing from this orientation will increase the level of harmful forces directed against the implants.²⁵ When angulation is nevertheless necessary, other biomechanical parameters, for example the number of implants and their primary stability (see Figs 4-3 and 4-4), should be optimal to outweigh these forces.

Sometimes an implant is deliberately anchored in cortical buccal bone to maximize primary stability.²⁶ The resulting fenestration of the buccal plate necessitates a lateral augmentation procedure to surround the implant with at least 1 mm of bone. This procedure is still in an experimental stage and cannot be routinely recommended.

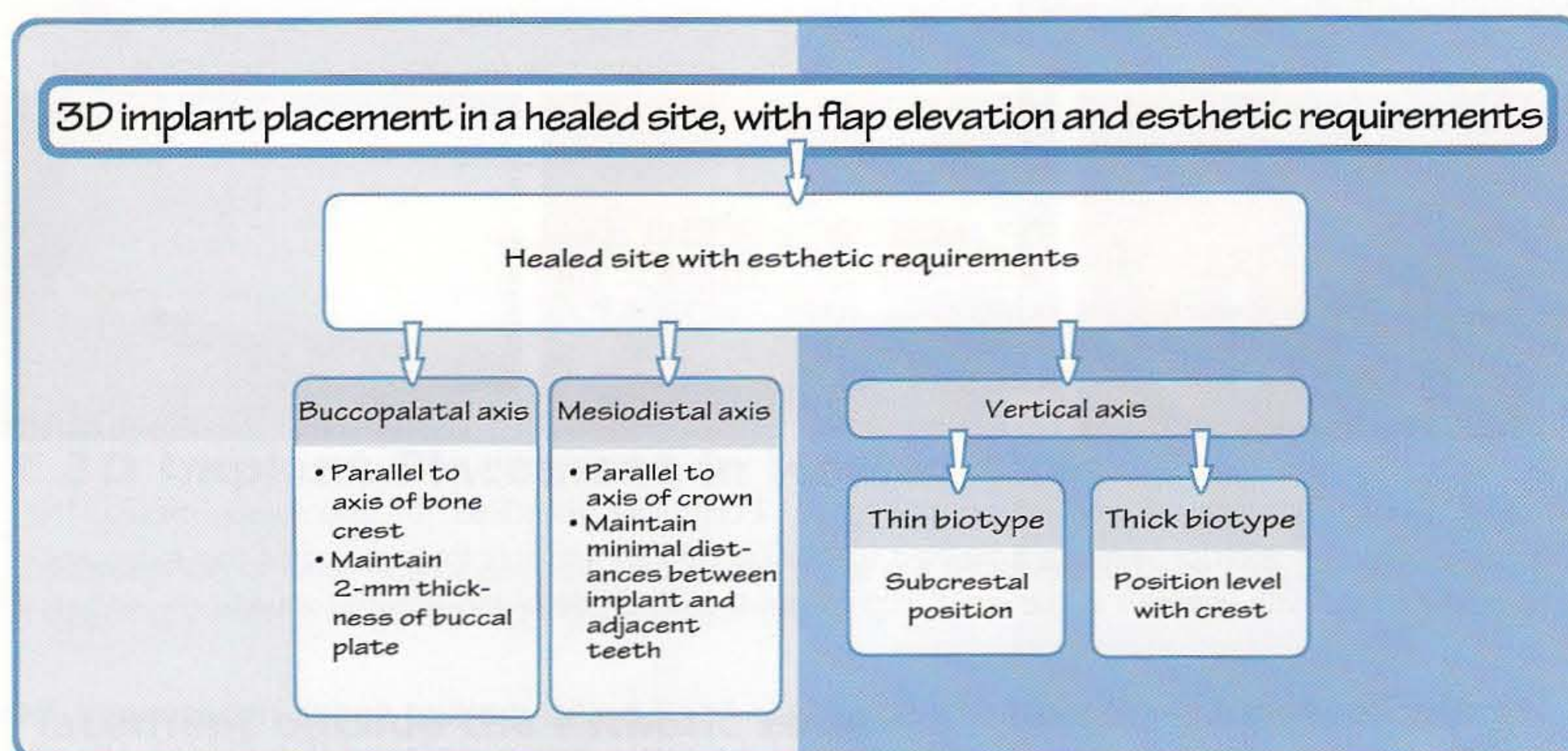
In treating the maxilla, clinicians should remember that the buccolingual axis is the most important factor determining the retention mode of the prosthesis, screw-retained or cemented. If the implant axis is inclined too far buccally, screw retention is contraindicated for esthetic reasons, because the screw access path emerges on the labial surface of the crown (Figs 5-12b and 5-12c).

Coronoapical positioning

In the absence of esthetic considerations, the most appropriate coronoapical implant placement may vary. Implant placement can be level with the crest, supracrestal, or subcrestal (Fig 5-13a) to



▲ **Fig 5-13** Coronoapical implant positioning. (a) Edentulous mandible. All types of implant positioning—level with the crest, supracrestal, or subcrestal—are applicable. (b) Edentulous mandible. Supracrestal placement facilitates abutment fixation. (c) Partially edentulous mandible. Placement that is level with the bone crest is usually indicated to facilitate the development of a harmonious emergence profile.



▲ **Fig 5-14** 3D implant positioning in a healed site when esthetics prevails. The most critical requirement is proper placement in the buccolingual and coronoapical directions.

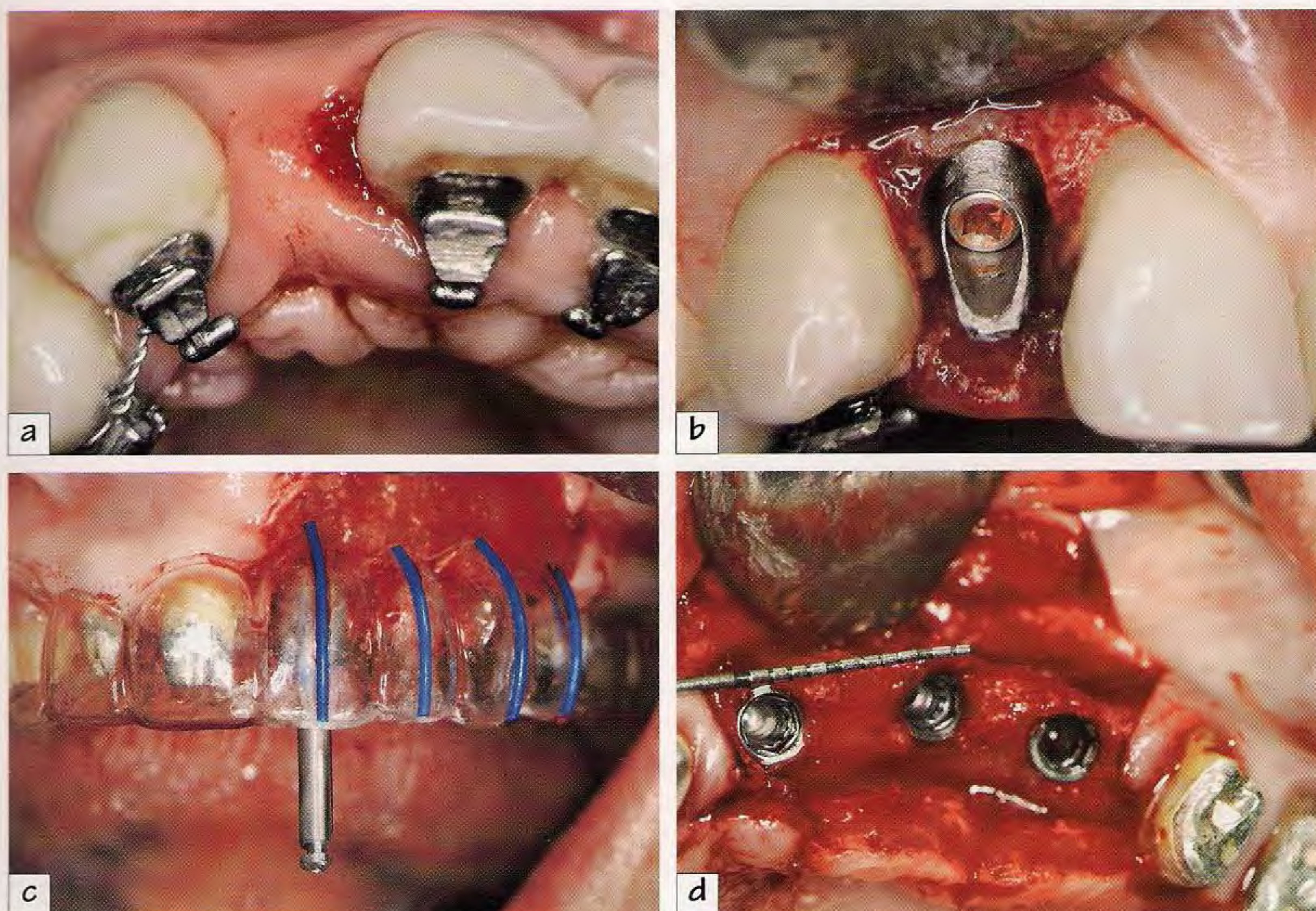
best serve considerations related to primary stability or prosthetic requirements, rather than esthetic considerations.

Supracrestal implant placement is preferable, because the implant-abutment junction will be above the bone crest. Abutment placement will be easier (Fig 5-13b), and vertical bone resorption will be minimized. However, implant placement can be level with the crest or subcrestal if such placement provides better primary stability.

In the partially edentulous jaw, implant placement is level with the crest, rather than supracrestal (Fig 5-13c), to facilitate creation of a harmonious emergence profile. In patients with a thin periodontal biotype, subcrestal implant placement has to be considered in anticipation of future gingival recession.

Placement in the esthetic zone

In the maxillary anterior segment, proper esthetic management of the soft tissues is essential; it requires stricter protocols for 3D implant placement (Fig 5-14).^{13,14}



▲ **Fig 5-15** Mesiodistal implant positioning. (*a and b*) Implant placement in a limited space. The implant should be placed in the middle of the available space to conform to the principles of minimum distance between the implant and the adjacent teeth. This is made possible with a narrow-diameter implant. (*c and d*) Determination of the number of implants that will preserve minimum distances between implants and between implants and teeth. If three implants are used to replace four missing teeth, the minimum distances required between implants and other implants or teeth are not violated. The mesiodistal axes of the three implants correspond to the axes of the supported crowns.

Mesiodistal positioning

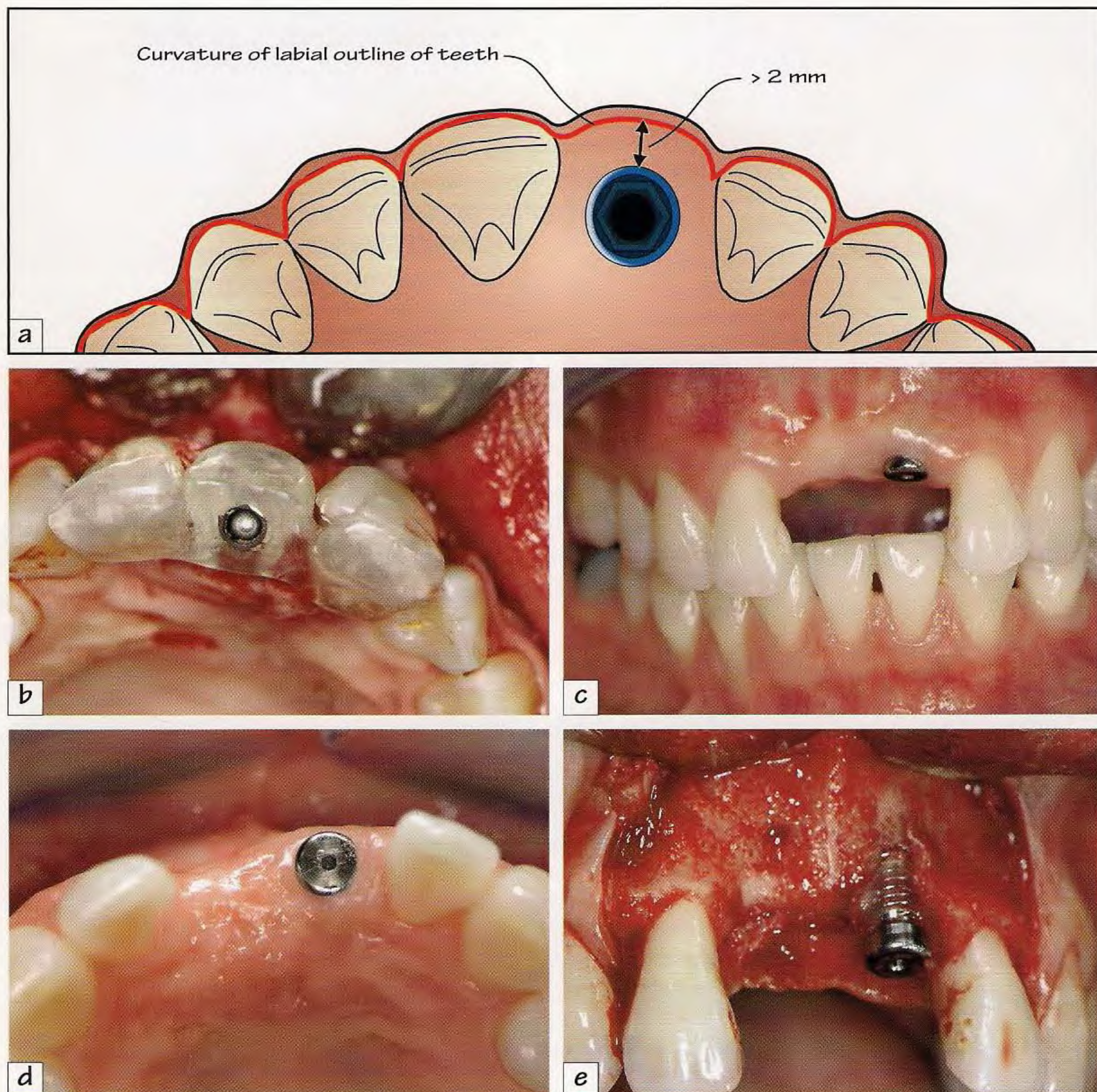
The minimal distance of 3.0 mm between implants and 1.5 mm between an implant and a natural tooth must be respected to ensure long-term stability of the papillae. The diameter and number of implants should be chosen accordingly (Fig 5-15).

The mesiodistal axis of the implant is parallel to the orientation of the crown that it supports (see Figs 5-15b and 5-15c). The implant is placed in the middle of the space available for rehabilitation, within the parameters of the minimum interimplant distance or the minimum distance between the implant and the adjacent teeth.

Buccopalatal positioning

Determination of the implant's buccopalatal position and axis should take into account the following considerations:

- The crown restoration should fit harmoniously in the curvature established by the adjacent natural teeth (Figs 5-16a and 5-16b).
- The buccal plate should be thicker than 2 mm at the implant site (see Fig 5-16a). This will ensure that sufficient bone support will remain for the overlying soft tissues after the inevitable



▲ **Fig 5-16** Buccopalatal implant positioning. (a) Correct implant placement. The implant must remain within the framework of the labial curvature of the adjacent teeth while maintaining at least a 2-mm-thick labial plate. (b) Buccopalatal axis of an anterior implant. This axis conforms to the limits of the labial curvature of adjacent teeth and allows the screw access hole to emerge exactly as expected at the level of the incisal cingulum. (c) Labial view of an implant that has been placed too far buccally. (d) Occlusal view of an implant that has been placed too far buccally. The required distance between the implant and the adjacent tooth has been respected, but the implant positioning violates the required thickness of 2 mm for the buccal cortical plate. (e) Bone resorption resulting from this encroachment.

vertical resorption of the first few months. When the buccal plate is less than 2 mm thick, osseous resorption results, and the final esthetics of the rehabilitation may be compromised (Figs 5-16c to 5-16e).

The buccopalatal implant axis should be compatible with the type of prosthesis selected, screw-type or cemented. If a screw-type prosthesis is planned, the screw axis hole should emerge at the level of the incisal cingulum (see Fig 5-16b), or the esthetic result may be compromised (see Fig 5-12c).

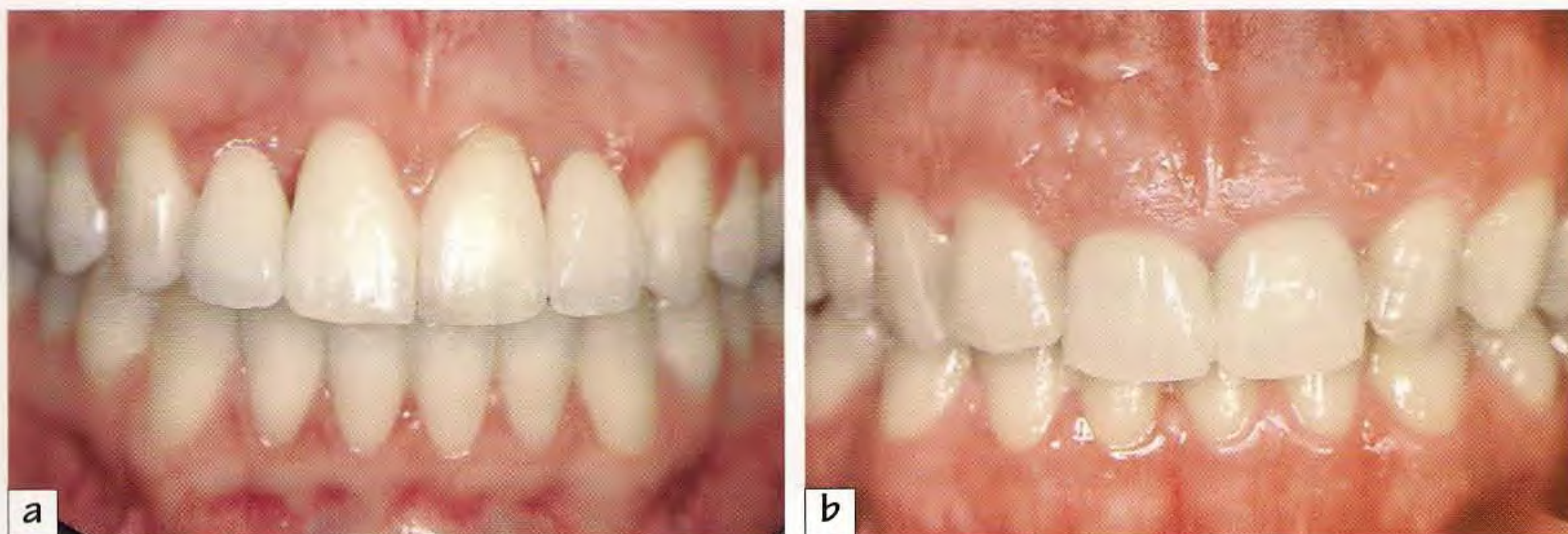


Fig 5-17 Periodontal biotypes. (a) Thin biotype. (b) Thick biotype.

Coronoapical positioning

The rules that govern the vertical positioning should be carefully respected, because this factor has a long-term influence on the presence or absence of gingival recession. From a purely biologic point of view and in consideration of the need to preserve the initial bone level, implants would best be placed in supracrestal position. However, because of esthetic requirements, only a crestal or subcrestal position will allow development of a harmonious emergence profile.

For the crown to complement the adjacent teeth, the implant neck must lie 2 to 3 mm below the level of their marginal gingivae. This position allows the laboratory technician to prepare a crown with a harmonious emergence profile and embrasures similar to those of the adjacent natural teeth.

When the implant site exhibits advanced bone resorption, it is no longer possible for the implant-supported restoration to maintain a harmonious relationship with the gingiva of surrounding adjacent teeth without reconstructive bone surgery. Similarly, papillae can only be preserved or restored when proper bone support is present.²⁷

Analysis of the periodontal biotype, to determine if it is thin or thick, allows the clinician to predict the extent of bone resorption that will occur and how the soft tissues will respond to that resorption¹³:

- The thin periodontal biotype is characterized by a thin, scalloped gingiva; it is poorly keratinized and has long, slim papillae (Fig 5-17a). Frequently, the teeth associated with this biotype are long and relatively thin, and they tend to be triangular. Their contact points are located closer to the incisal edge in the coronal third of the crown. The mesiodistal width of the roots decreases rapidly from the cemento-enamel junction to the apex, all of which lends a slender appearance to radiographic images.
- The thick periodontal biotype is characterized by a thick, flat, well-keratinized gingiva; papillae are short and blunt (Fig 5-17b). In this type of periodontal tissue, teeth are often large and square. Their contact points are located in the apical third of the crown. The mesiodistal width of the roots decreases in a slow progression apically, giving the teeth a massive appearance.

The coronoapical implant positioning varies depending on the periodontal biotype (see Fig 5-14):

- When the biotype is thick, the implant should be placed level with the crest or subcrestally. Usually, this biotype undergoes limited bone resorption and gingival recession in the apical direction as a response to implant placement. The factors governing bone resorption are surgical trauma and insults at the implant-abutment junction. Placement level with the crest will precipitate the least bone resorption, but sometimes subcrestal placement is required even for patients with a dense periodontal biotype, to ensure eventual harmony with the gingival margins of adjacent teeth.
- When the biotype is thin, the response to implant placement is bone resorption and gingival recession to preserve the biologic width. The implant should be placed subcrestally to anticipate this inevitable tissue recession. Often, a gingival graft is needed to compensate for the gingival recession.

When the emergence site is located too far palatally, the emergence profile can be improved by placing the implant neck deeper in the bone. For every 1-mm displacement in the palatal direction, the implant neck should be placed 1 mm deeper in bone.²⁸

▼ 3D Implant Placement in Extraction Sites

Advantages of immediate loading

In an extraction site, the protocol of choice in the anterior area—where esthetics is essential—is immediate placement and immediate loading. Treatment time can vary from 1 to 72 hours, depending on the patient's psychologic tolerance and the laboratory requirements related to the option selected for prosthetic treatment. Extraction and immediate restorative treatment may be provided for the following reasons:

- Subgingival crown fracture
- Vertical root fracture
- Poor prognosis for a mobile tooth
- Advanced root resorption

Use of an immediate-loading protocol in extraction sites has several advantages: the patient's appearance is restored promptly, bone loss is kept to a minimum, and the original gingival tissue contour can be preserved.

This rapid treatment protocol has some prerequisites and modifications:

- The involved alveolar process must be free of all acute infection.
- The buccal plate must be preserved in toto.
- 3D implant positioning in the anterior maxilla is modified from that used in a healed site.
- When esthetic considerations are critical, every effort should be made to place the implant without raising a flap. This, however, will prevent direct visualization of osseous landmarks.

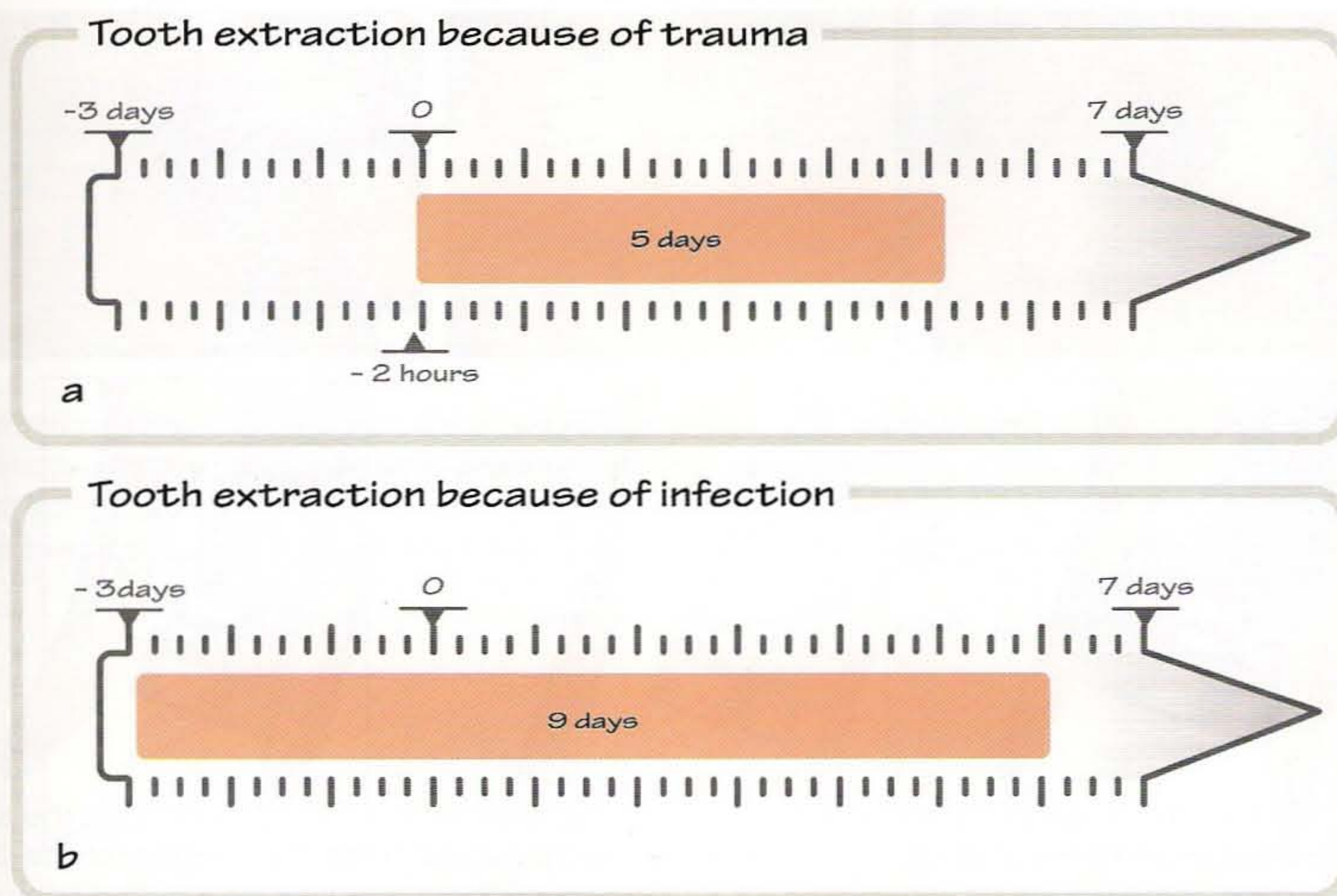
When teeth have to be extracted because of trauma, infection is usually either limited or absent. Pretreatment antibiotic prophylaxis that begins 2 hours before the procedure will be sufficient (Fig 5-18).

When teeth are extracted because of infection, antibiotic prophylaxis begins 3 days before implant placement. Treatment of the infection consists of enucleation of granulation tissue and abundant lavage of the extraction socket with physiologic saline. Depending on the severity of the infection, antibiotic treatment may have to be followed up 5 to 7 days after extraction (see Fig 5-18).

Implant positioning

The procedure for placing an implant in an extraction site varies, depending on whether the site originally housed a single or a multirouted tooth and whether or not esthetic considerations are important.

The simplest treatment is replacement of a single-rooted tooth in a site where esthetics does not prevail. The primary goal of this procedure is to achieve primary stability in the extraction socket. In multirouted sites, the goal is similar but more difficult to realize. In such cases root anatomy is an important factor because implants rarely fill the complete extraction site. Implants instead are placed in the middle of the extraction site, between the alveoli of the roots, in a manner that suits their 3D positioning. In this position, bone in the interradicular area must be sufficient to ensure primary stability. The surgeon must drill 3 to 5 mm beyond the apex of the alveolus to achieve stability. The use of wide-diameter implants is helpful to increase primary stability when a cortical plate is involved. The diameter selected must, however, conform to the minimal distances between implants and teeth or between implants.



▲ **Fig 5-18** Administration of medications. The timing of prophylactic antibiotic administration depends on the cause of the tooth extraction. (a) Traumatic etiology. (b) Infectious etiology. Red bars represent the duration of administration.

When esthetic requirements are critical, treatment of an extraction site must address specific issues:

- The most suitable implant diameter
- The proper buccopalatal implant axis in relation to the alveolar axis
- The coronoapical implant position with respect to the osseous crest when implant placement is performed without flap elevation

In contrast, the mesiodistal axis is more easily defined because it usually conforms to the axis of the alveolus. It is even possible to maintain a preexisting anterior diastema when the implants are placed in the extraction sites (Fig 5-19).

Implant diameter

The implant diameter is selected in accordance with these criteria:

- The implant should fill the socket to maximize primary stability. This is usually best achieved with a conical implant or a wide-neck cylindrical implant to fill the alveolus in the coronal area.²⁹
- The buccal cortical plate should be carefully preserved by leaving at least 2.0 mm between the external wall of the plate and the external edge of the implant.¹³
- A distance of at least 3.0 mm should be maintained between implants, and a distance of at least 1.5 mm should be maintained between an implant and an adjacent natural tooth.¹⁴

Buccolingual implant axis

The buccolingual axis of the implant placed in an extraction socket need not necessarily conform to the axis of the alveolus of the extracted tooth. Posteriorly, the buccal angulation of the osseous plate is limited; in addition, posterior teeth are usually larger in diameter than standard implants. Therefore, implants are readily placed in the center of an extraction socket without infringing on the buccal plate.



▲ **Fig 5-19** Mesiodistal implant positioning in an extraction site where there was a preexisting diastema. (a) Appearance of the diastema in the natural dentition. (b) Provisional prosthesis loaded immediately after implant placement. The provisional restoration reproduces the preexisting diastema. (c) Occlusal view of the provisional prosthesis. The metal retaining bar connects the two incisors and preserves the appearance of the original diastema.

This is not the case with the single-rooted maxillary anterior teeth. There, drilling along the axis of the extracted tooth to enlarge the osteotomy frequently undermines the integrity of the thin buccal plate. Bone resorption usually follows, reducing support for marginal gingiva and compromising the eventual esthetic result. For that reason, the implant axis is modified to leave the buccal plate at a distance from the osteotomy. Drilling has to be angulated more palatally, by about 5 degrees, to preserve a 2-mm distance between the edge of the implant and the border of the cortical bone and to establish anchorage for the implant within the cortical palatal plate and increase primary stability.

Management of the implant-alveolus gap

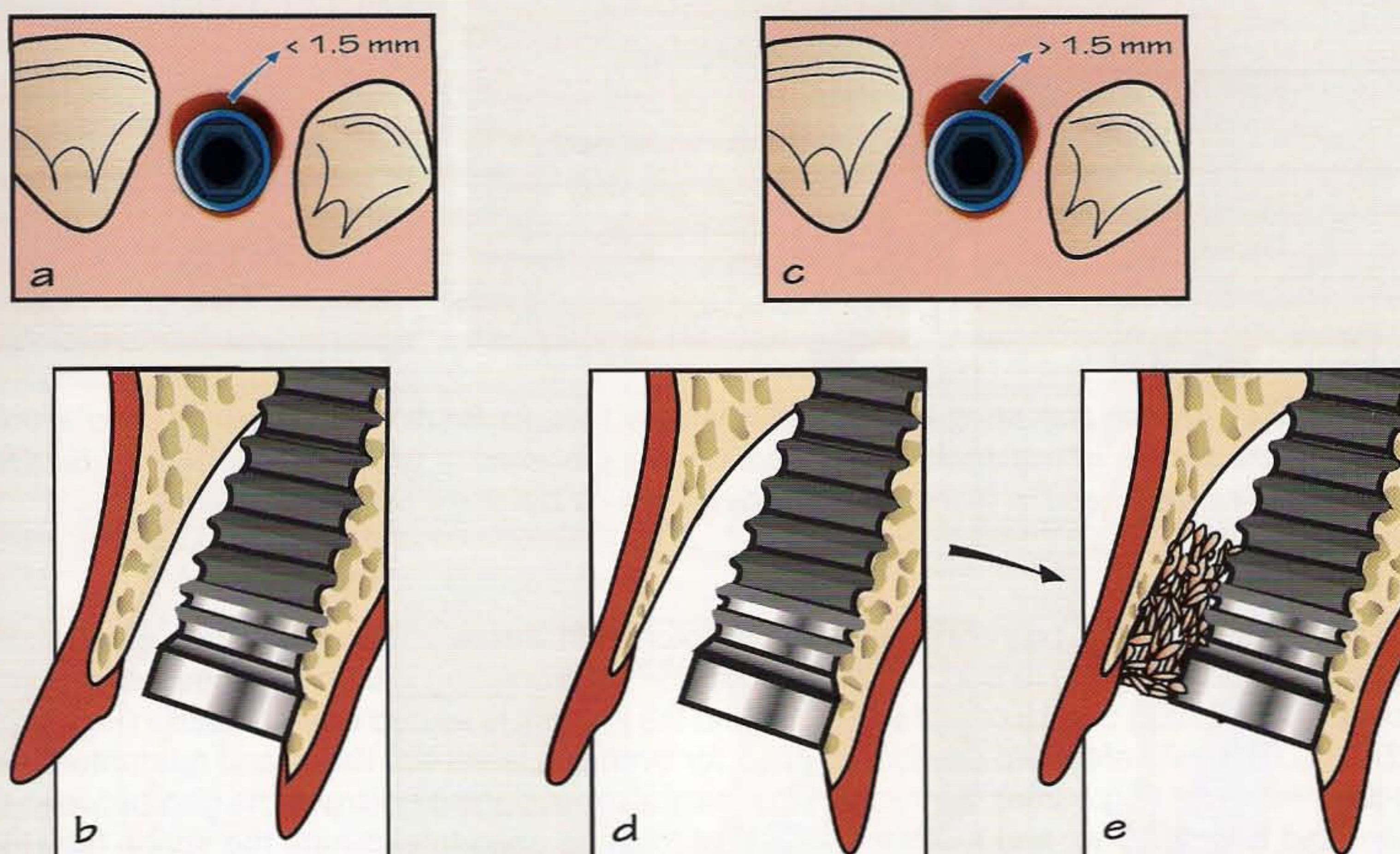
Sometimes, the socket is wider, mesiodistally or buccopalatally, than the implant that is placed in it. The gap left between the implant and the alveolar wall must heal and be filled with newly formed bone, or the soft tissue will lack hard tissue support and will migrate apically. If the gap is less than 1.5 mm (Fig 5-20a and 5-20b), tissue growth will fill it spontaneously without subsequent vertical bone loss.^{30,31} However, if the space is 1.5 mm or greater (Fig 5-20c to 5-20e), bone will regenerate but will lose vertical height, eventually reducing support for the gingival marginal tissue and papilla. Hence, to preserve soft tissue integrity, large gaps (Fig 5-21a) must be filled with autogenous bone (Fig 5-21b), a filling material, or a combination of the two.

Although the objective is to maintain or reconstitute adequate bone support for gingival or papillary contour, the entire gap does not have to be filled; only the most coronal 2 mm of the gap contacting the surrounding soft tissues requires augmentation (see Fig 5-20b). In the apical part of the gap, new bone formation will eliminate the intraosseous space without assistance. The coronal part of the gap is best filled with autogenous bone obtained from extension of the alveolar cavity drilled beyond the apex (Fig 5-21c).

Anterior sites

Mandibular anterior sites

Esthetic considerations are rarely critical when missing mandibular anterior teeth are replaced. The guidelines for 3D positioning in such cases have been previously discussed (see Fig 5-10). Implants placed in the extracted sockets will usually fill the available spaces, except those left by canines. Most small-diameter implants fit the dimension of these teeth. In canine regions, residual gaps of 1.5 mm or more between the implant and the alveolar walls should be augmented with autogenous bone or a substitute (Fig 5-22).



▲ **Fig 5-20** Management of the gap between an implant and the alveolar walls. (a) Occlusal view and (b) longitudinal section of a gap of less than 1.5 mm. A gap of this size need not be filled. (c) Occlusal view and (d) longitudinal section of a gap of 1.5 mm or more. (e) The 2.0-mm crestal gap must be augmented; only with a gap of less than 1.5 mm will natural bone regenerate to eliminate the space.



▲ **Fig 5-21** Management of the gap between an implant and the alveolar walls. (a) The gap between the implant and the buccal wall is greater than 1.5 mm. (b) Autogenous bone was obtained when the socket was drilled beyond the apex. (c) The gap has been filled with autogenous bone. No sutures are required.

Maxillary anterior sites

Specific criteria apply to the placement of implants in the anterior maxilla with regard to both the buccopalatal and mesiodistal axes. The aim is to maintain adequate long-term osseous support for the soft tissues and avoid gingival recession.

Because of the pronounced labial axial inclination of the anterior teeth (Fig 5-23a), if the implant axis follows the alveolar axis, the osteotomy can encroach on the already delicate and fragile buccal plate or at best result in a less than 2-mm thickness of bone at the top of the osteotomy (Figs 5-23b and 5-23c). To prevent this occurrence, the implant axis should be angled about 5 degrees more palatally than the tooth axis (Figs 5-23d, 5-23e, and 5-24).¹³ To change the axis and reestablish a distance of at least 2 mm between the implant neck and the buccal bone, a round bur is used to prepare a notch on the palatal cortical plate, at the lower third of the socket (Fig 5-25a). Skidding



▲ **Fig 5-22** Implant positioning in mandibular anterior sites. (a) Relationship of implants and alveoli. Implants fill the sockets of mandibular incisors, but often a gap exists in canine sites (*arrow*). (b) Bio-Oss (Osteohealth) has been used to fill the gap in the canine site. (c) The alveoli are sutured.

is difficult to avoid while preparing the palatal notch with a rotary instrument; use of ultrasonic surgery tips (piezosurgery) aids in this critical step.^{32,33} The opening is then enlarged with a normal sequence of burs (Fig 5-25b) or vibrating tips, and the implant is seated more palatally (Figs 5-25c and 5-25d). This will safeguard osseous support for overlying labial soft tissue and guarantee good long-term esthetics (Fig 5-25e). Sometimes this palatal repositioning enlarges the gap between the implant and buccal bone, and restorative material must be used to eliminate the space (see Figs 5-20d and 5-20e).

Premolar sites

Mandibular premolar sites

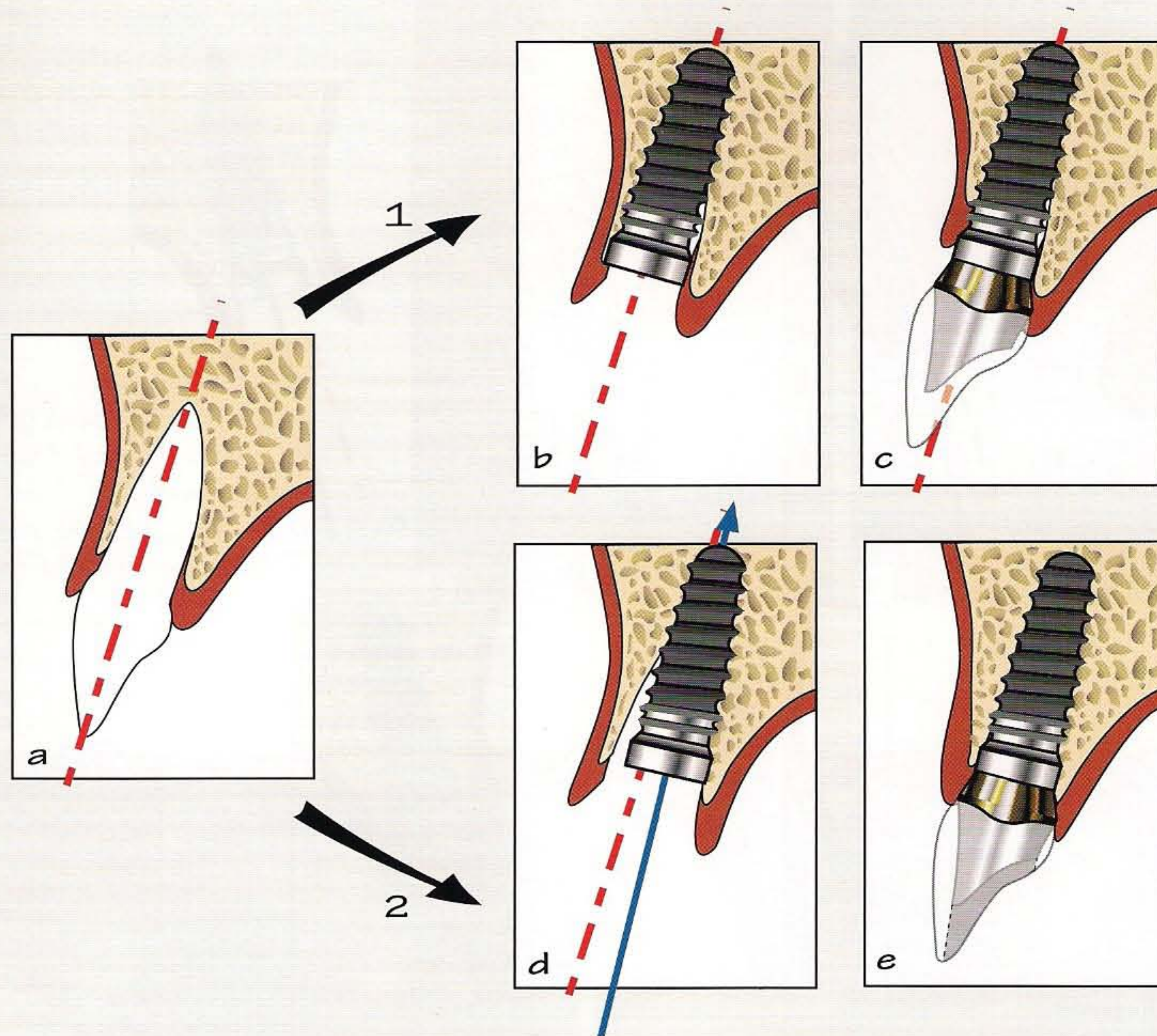
There is usually no specific difficulty in obtaining primary stability when an implant is placed in the socket of a premolar. The buccal and lingual roots of the tooth are as a rule fused, and the mesiodistal dimension is usually smaller than the buccolingual dimension. In addition, esthetic considerations at these sites are rarely important.

The recommendations previously listed for implant placement in the anterior sector apply (see Fig 5-10). Implants usually fill the mesiodistal dimension of the socket (Fig 5-26). When a gap exists buccolingually, the surgeon will have to decide whether it is large enough to require use of a bone substitute.

Maxillary premolar sites

The buccal and palatal roots of the maxillary premolars, especially the first premolar, are generally separate, and neither of the alveoli offers adequate space for implant placement. The best site is usually found in the region once occupied by the interradicular septum. Depending on their inclusion in the smile line and on arch form, these sites are often of esthetic importance.

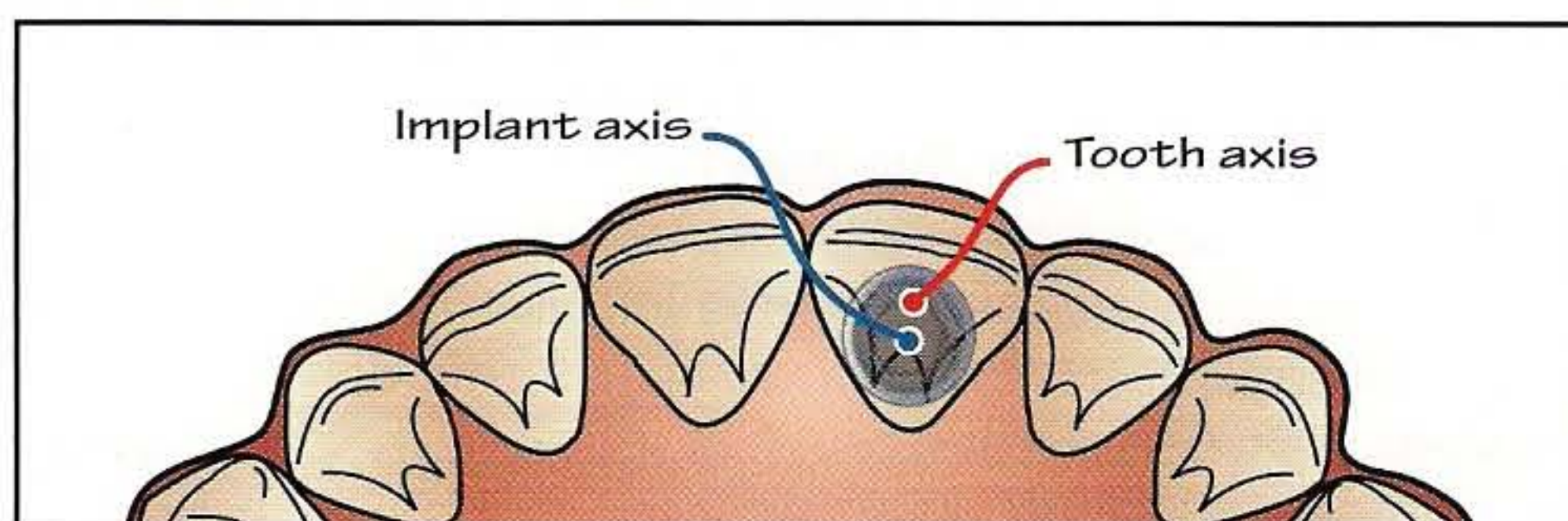
In view of their visibility, 3D implant positioning follows the principles applied to sites where esthetics is important (see Fig 5-14). Depending on the biotype and thickness of the soft tissue in the region, the implant neck is placed level with the crest or subcrestally. Implants usually fill the mesiodistal dimension of the socket (Fig 5-27). When a gap exists buccopalatally, the surgeon must decide whether it is large enough to require use of a bone substitute.

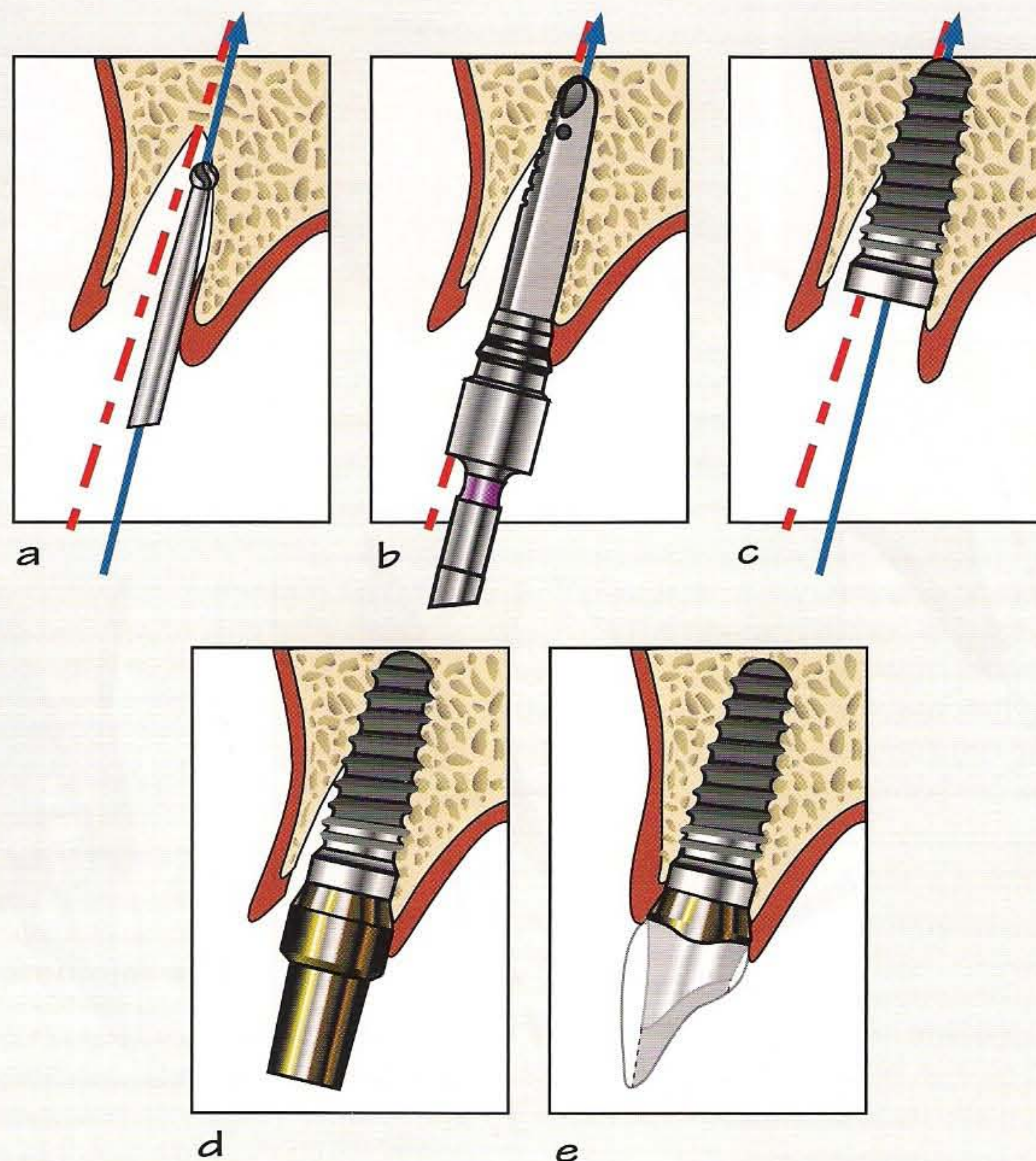


▲ **Fig 5-23** Implant positioning in the buccopalatal axis. (a) Original axis of the tooth in the alveolus. Arrow 1 shows the course of events when implant axis coincides with the axis of the extraction socket. (b) When the implant is positioned along the tooth axis, the implant encroaches on the buccal plate, and the coronal part of the cortical plate is less than 2 mm thick. (c) The buccal plate has resorbed because of its insufficient thickness. The overlying soft tissues have migrated apically owing to lack of support, and a good esthetic result has been compromised. Arrow 2 shows the course of events when the implant axis has been directed 5 degrees more palatally than that of the natural tooth. (d) When the positioning of the implant is altered from the natural tooth axis, the coronal part of the buccal cortical plate is more than 2 mm thick. (e) Bone regeneration can proceed without any resultant resorption. The bony support for soft tissues has been maintained, preventing their apical migration and guaranteeing satisfactory long-term esthetics.

► **Fig 5-24**

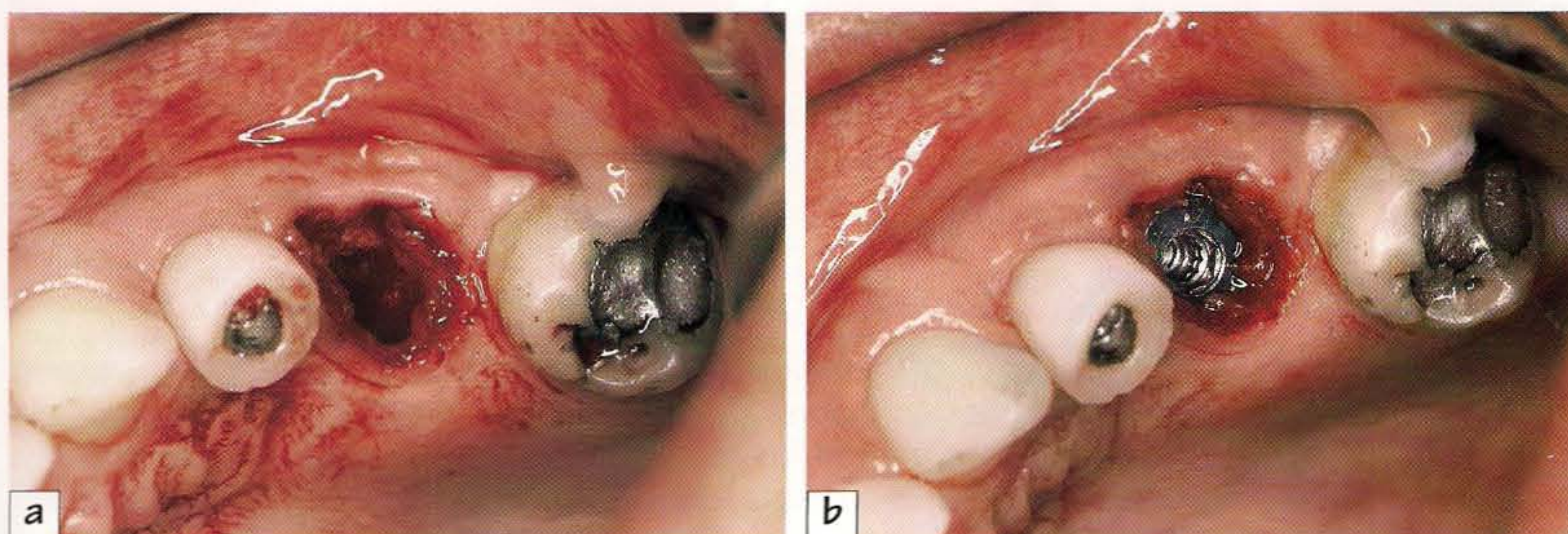
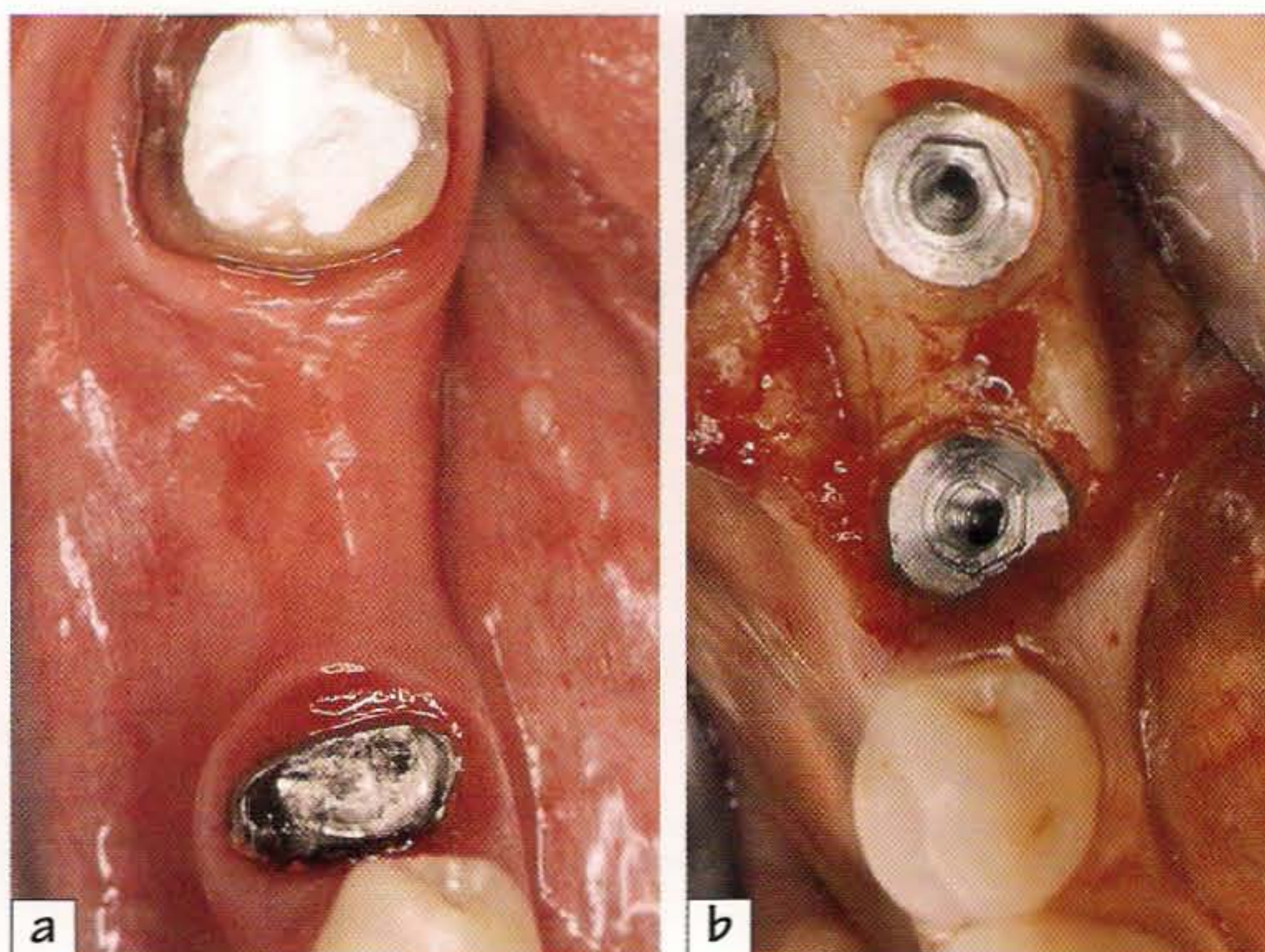
Palatal shift of 5 degrees between the tooth axis and the implant axis. Because of this alteration in angulation, the implant has not encroached on the buccal cortical plate, and the anterior rim of the buccal plate and the edge of the implant remain at a safe 2-mm distance.¹³





▲ **Fig 5-25** Preparation of an implant axis that differs from that of the natural tooth and the resultant impact on soft tissues. (a) Creation of a notch on the palatal wall at the apical third of the extraction socket. Tooth axis (red line); implant axis (blue line). (b) Drilling sequence. The osteotomy is further processed with a normal series of burs. The implant axis (blue line) is moved palatally with respect to the tooth axis (red line). (c) Implant placement at a different inclination (blue line) from that of the natural tooth (red line). This leaves the buccal plate at least 2 mm away from the implant. (d) Titanium abutment screwed into the implant. Eventually, the soft tissues will come in contact with the abutment and receive support. (e) Bone regeneration proceeds without specific resorption of the buccal plate. The soft tissues develop on a sturdy bony support, enough to provide good long-term esthetics.

► **Fig 5-26** Implant placement in a mandibular premolar site. (a) Clinical view before extraction. (b) Implant placement. The implant fills the socket of the extracted tooth.



▲ **Fig 5-27** Implant placement in a maxillary premolar site. (a) Socket after extraction. (b) Placement of a wide-platform implant. The neck completely fills the crest of the socket.

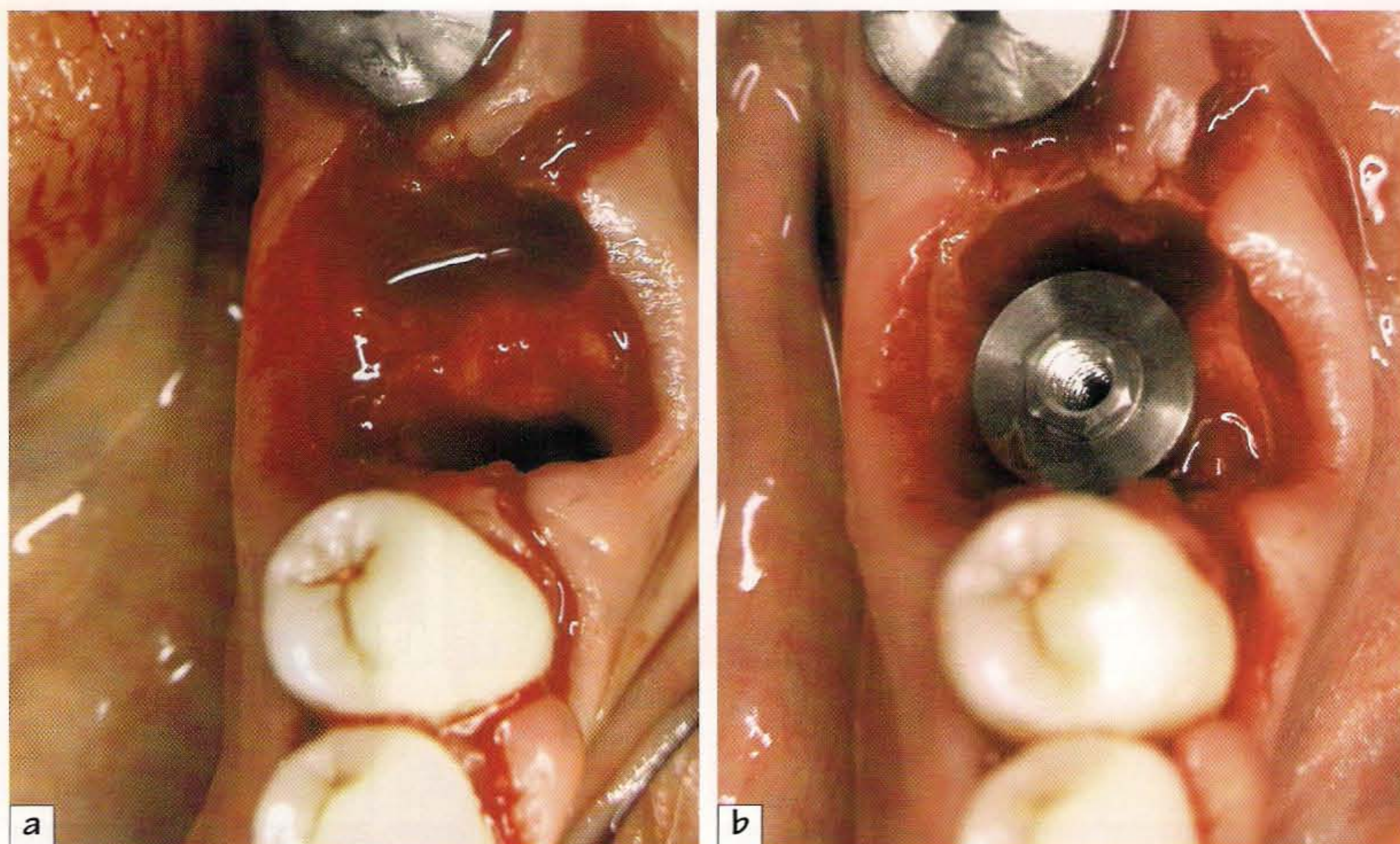
Molar sites

Mandibular molar sites

The mesial and distal roots of mandibular molars are well separated by a septum (Fig 5-28a). This septum is often large enough to receive an implant 5 to 6 mm in diameter, whose primary stability will be satisfactory (Fig 5-28b). In these sites, esthetic considerations are almost never important, and the mesiodistal dimension is greater than the buccolingual dimension.

Implant placement in these sites follows the principles for 3D positioning already described for sectors that do not have esthetic considerations (see Fig 5-10). In mandibular molar sites, implants do not fill the available space either mesiodistally or buccolingually (see Fig 5-28b), sometimes falling more than 2 mm short. When this happens, good primary stability can be difficult to obtain, and it might be wise to postpone loading and follow a standard delayed-loading protocol.





▲ **Fig 5-28** Implant placement in a mandibular molar site. (a) Socket after extraction. (b) Placement of a 6-mm-diameter implant in the septum between the roots. The socket is not filled mesiodistally or buccolingually.

Maxillary molar sites

The three roots, buccal and palatal, of maxillary molars are separated by septa of varying dimensions. Some authors have suggested the use of two implants to replace a molar.³⁴ However, the introduction of larger implants to the market has made that compromise solution unnecessary. Depending on the extent of the space between septa, primary stability may or may not be achieved after implant placement. The mesiodistal distance is greater than the buccolingual dimension.

For maxillary molar sockets, implant placement follows the principles for 3D positioning already described for sectors without esthetic considerations (see Fig 5-10). Usually, implants fail to fill the available alveolar space in both the mesiodistal and buccolingual directions, sometimes leaving a gap of more than 2 mm. When this happens, as with mandibular molars, good primary stability can be difficult to obtain, and it might be wise to postpone loading for several months.

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Chapter 6

MANAGEMENT OF ESTHETICS

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This chapter discusses the various ways clinicians can obtain the best esthetic results for implant-supported prostheses. In order to be recognized as an acceptable alternative to delayed-loading procedures, immediate-loading protocols must be able to demonstrate long-term osseointegration and success rates at least as high as those achieved with traditional procedures. In addition, the esthetic results, including a harmonious blending into the arch and long-term preservation of well-supported papillae and gingival margins, must be similar to those provided by the protocols the present method wishes to supplant.

For delayed-loading protocols, average gingival recession of 0.40 to 0.60 mm, and even 1.00 mm, has been reported as occurring within 6 months after placement of the prosthesis.^{1,2} Little has been published, as yet, about soft tissue results for immediate-loading protocols. Some studies have stressed the importance of a provisional prosthetic phase of at least 6 months for stabilizing soft tissues.^{3,4} Gingival recession reached 0.75 to 1.50 mm for immediately loaded implants,³ similar to that reported for delayed loading.

The parameters affecting esthetic outcomes are numerous and varied, and efforts to catalog them have been rudimentary. Some parameters have been isolated and studied in vivo, but their effects have not been confirmed by careful and well-documented clinical studies. At this stage, clinicians would be well advised to incorporate those parameters and practices that have given the best in vivo results. Many methods are available for optimizing esthetic results, including:

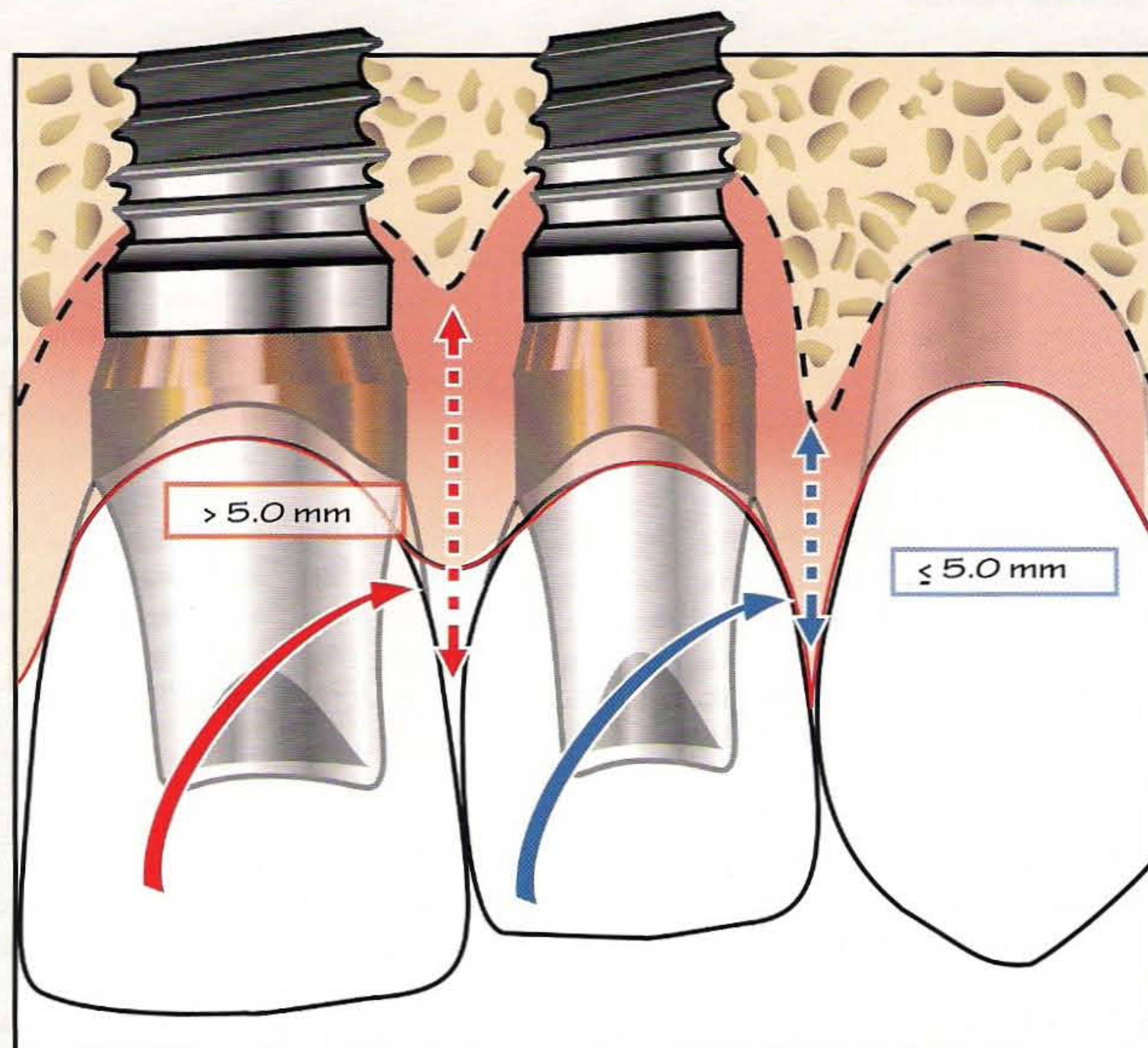
- Incision design or avoidance of flap elevation
- Optimal placement of the implant-abutment junction in relation to soft and hard issues
- Maintenance of a proper implant distance from other implants and natural teeth
- Application of the principle of platform switching
- Preparation of a provisional prosthesis capable of soft tissue guidance

To preserve the integrity of the marginal gingiva and papillae around implants over the long term, clinicians should keep in mind the following three principles:

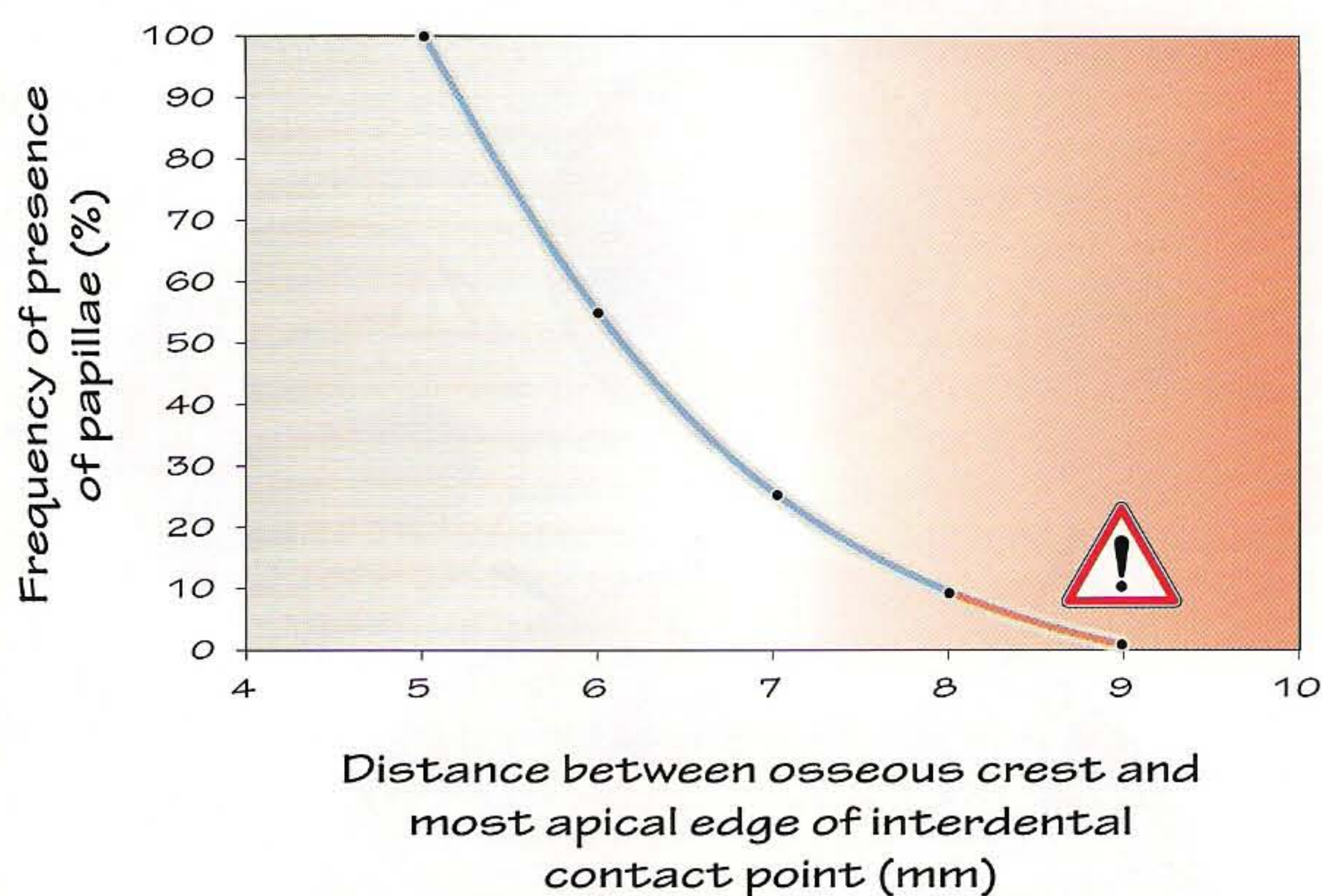
1. All soft tissue must be supported by underlying hard tissue. When bone level migrates apically, the soft tissue above it inevitably moves in the same direction.⁵⁻⁸
2. For papillae to remain in their shape and position, the distance between the bone crest and the most coronal point of the papillae must be limited.⁵⁻⁸
3. For soft tissues to remain in shape and position, a minimum distance must be maintained between implants and adjacent teeth or other implants.⁶

▼ Relationship Between Soft and Hard Tissues

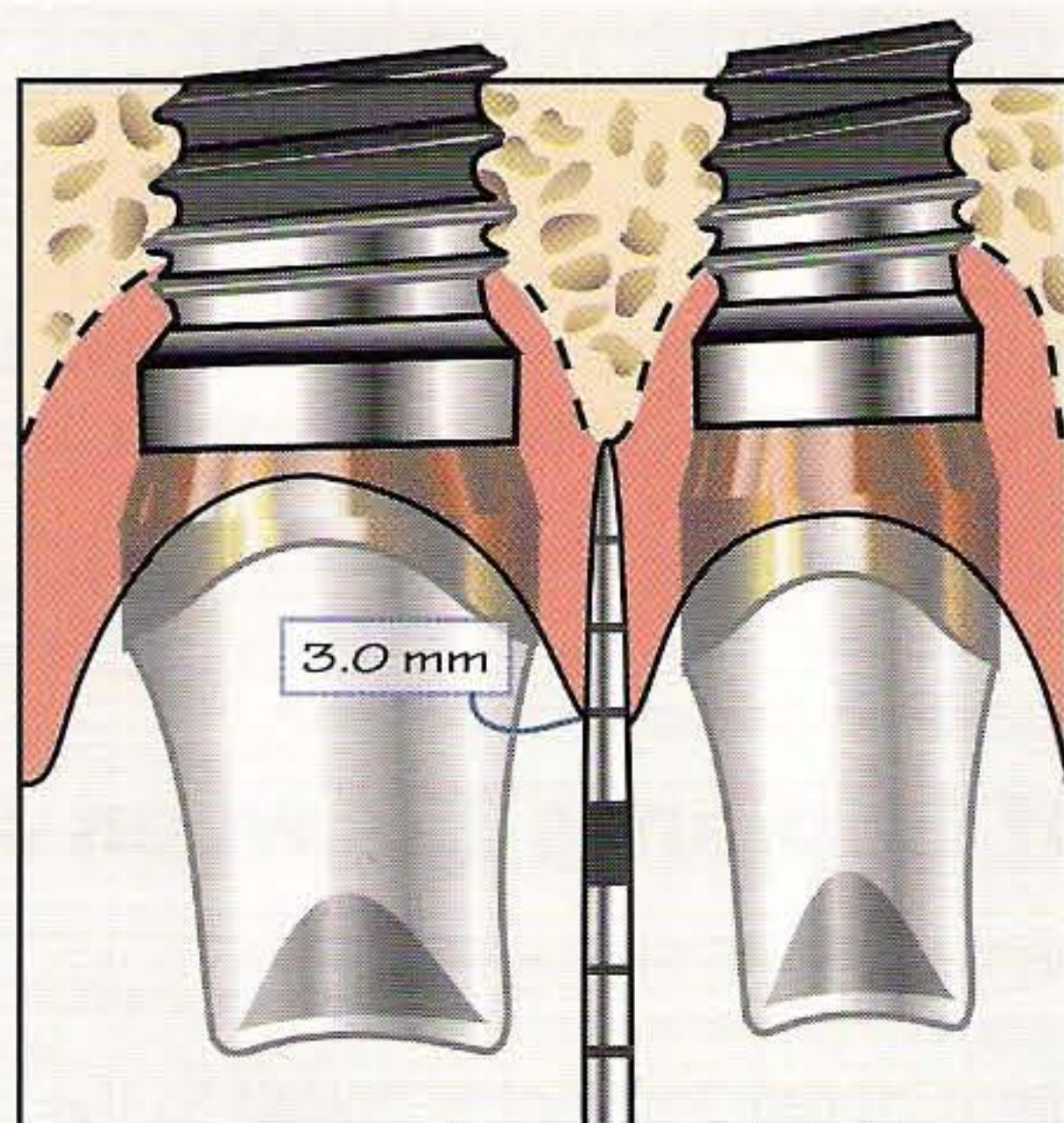
For a papilla to survive, an osseous crest must be present between teeth or between implants. Therefore, the crest-to-papilla distance that will be most conducive to good support must be determined. One study⁵ dealing with natural teeth has evaluated the distance between the alveolar crest and the most apical part of the contact point between two crowns (Fig 6-1). When this distance is 5 mm or less, the papilla is always present; at 6 mm it is present only in 55% of cases (Fig 6-2). With an increase in crest-to-contact point distance, the probability that a papilla will exist declines.⁵ Mathematic extrapolation of the curve shows that, as that distance approaches 9 mm, no papilla will be present at all (see Fig 6-2). At that measurement, bone is too far away to effectively support the soft tissue.



▲ **Fig 6-1** Principle for determining the distance between the bone crest and the most apical part of the contact point for teeth and implants. Between tooth and implant, the papilla (red shading) is always present (solid blue arrow) when the distance is 5 mm or less (dotted blue arrow). When the distance between two implants is greater than 5 mm (dotted red arrow), the papilla is usually absent (solid red arrow).

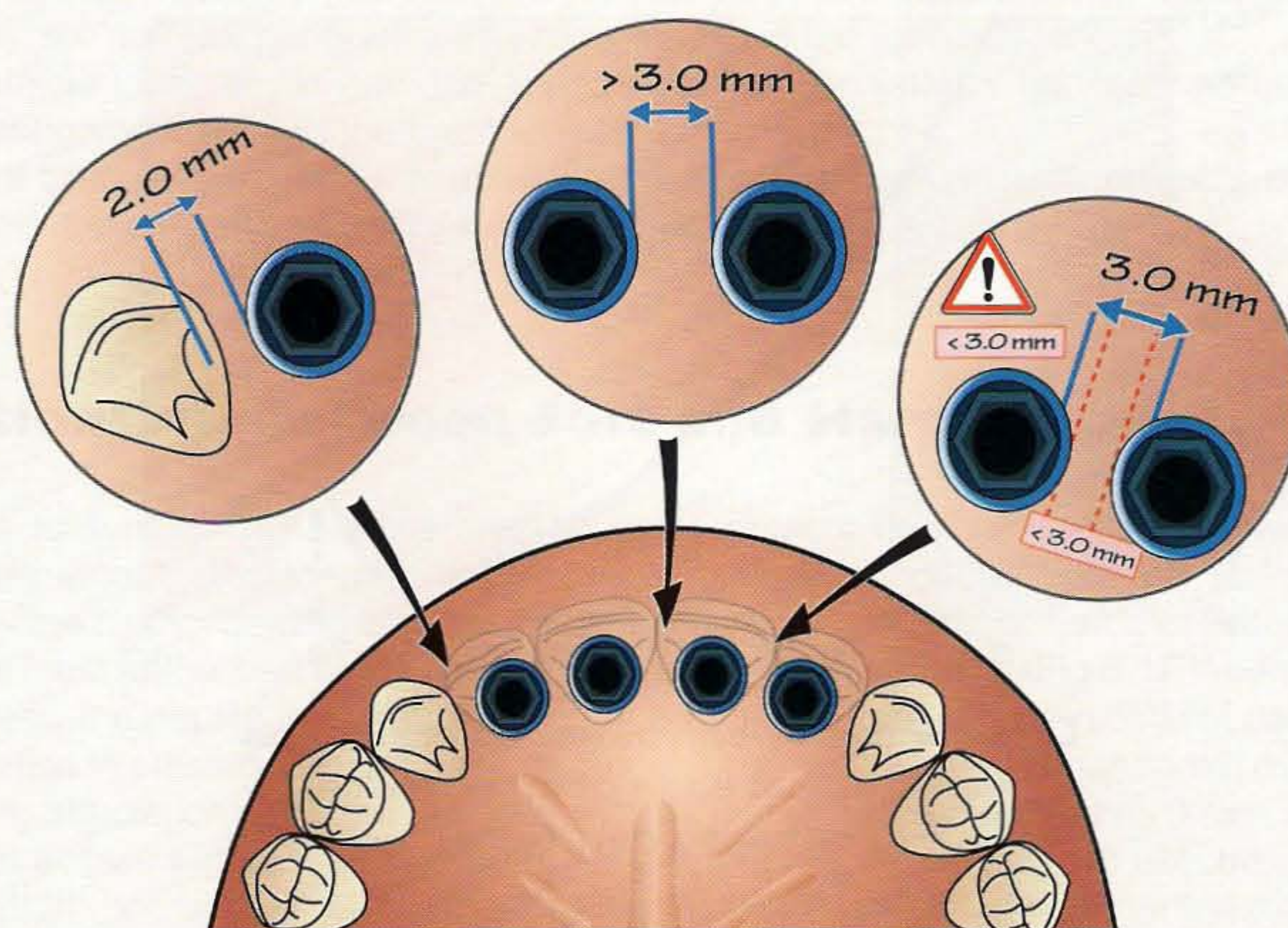


▲ **Fig 6-2** Relationship between the distance from the bone crest to the most apical edge of the interdental contact point and the presence of papillae. The papilla is always present when the distance is 5 mm or less. The frequency of its presence decreases when the distance increases. The blue portion of the curve in the diagram depicts actual measurements.⁷ The portion between 8 and 9 mm was mathematically extrapolated.



▲ **Fig 6-3** Measurement between the bone crest and the most apical edge of the interimplant contact point when the papilla is present. This measurement averages 3.4 mm. The most frequently recorded values are 2.0, 3.0, and 4.0 mm. In the diagram, the recorded value is 3.0 mm.

The maximum distance that will provide support to the papilla is shorter between two implants than between an implant and a tooth. The crest-to-papilla distance between two implants is, on average, 3.4 mm, and the most frequent measurements are 2.0, 3.0, and 4.0 mm (Fig 6-3).⁷ Beyond 4.0 mm, extrapolation indicates that papillae are consistently absent. Papillae between natural teeth may fare better because of the increased vascularization conferred by the periodontal ligament. For this reason, the presence of the papilla between an implant and a natural tooth is governed by the criteria applying to natural teeth.



▲ **Fig 6-4** Optimum mesiodistal distances between adjacent units. Implants should be placed at a distance of at least 1.5 mm, but preferably 2.0 mm, from an adjacent natural tooth. Adjacent implants should be placed at least 3.0 mm apart. In the anterior maxilla, an increase of this distance is even better to ensure the best possible osseous support for interincisal papillae.

These principles underscore the importance of maintaining a bone crest between teeth and implants to support papillae. This justifies all efforts to preserve the crest through favorable three-dimensional (3D) implant placement.

▼ 3D Positioning of Implants Between Adjacent Structures

A satisfactory esthetic result with a dental implant is linked to the presence of papillae and good gingival margins and their long-term stability. Correct implant positioning assists in the preservation of the osseous buccal and interproximal support. Although the rules for implant positioning were addressed in chapter 5, this chapter will discuss them in a more specific esthetic context.

To preserve the osseous level between two adjacent dental units, required minimum distances between them must be respected. Between a tooth and an implant, this distance should be at least 1.5 mm, and a distance of 2.0 mm is preferable (Fig 6-4). Between two implants, at least 3.0 mm is required (see Fig 6-4). When these minimum distances are present, the osseous crest between the two dental units will survive even after some horizontal bone resorption has taken place.

When developing treatment plans, clinicians must take into consideration that insults at the implant-abutment junction, either infectious or biomechanical, will chronically assault the nearby bone crest. This will cause a defensive reaction that stimulates bone resorption in an apical direction. Bone resorption is followed by resorption of the epithelial tissue–connective tissue protective structure, in accordance with the principle of conservation of the biologic width. Thus, during the first few months an implant is in function, about 1.0 to 1.5 mm of craterlike bone

resorption develops around the implant-abutment junction. This is an expression of the principle of conservation of the biologic width in the mesiodistal and buccolingual planes.

When the mesiodistal distance between two implants is less than the desirable 3.0 mm (2×1.5 mm), the interimplant lamella is entirely eroded and can no longer support the papilla between the units (see Figs 5-6a and 5-6b). When the distance between implants is 3.0 mm or more, the lamellar bone between the implants remains and the papilla receives the needed support (see Figs 5-6c and 5-6d).

Similarly, when the distance between a natural tooth and an implant is less than 1.5 mm, the crater around the implant-abutment junction affects the bone next to the tooth; the periodontium is eroded and can no longer support the papilla (see Figs 5-6a and 5-6b). When the distance between the natural tooth and the implant is 1.5 mm or greater, the crater does not reach the tooth, and the papilla receives the needed support (see Figs 5-6c and 5-6d).

In the buccolingual plane, when the distance between the buccal border of the buccal plate and the implant-abutment junction is 2 mm or more (Fig 6-5a), resorption of the cortical plate is only partial and craterlike (Fig 6-5b). Enough osseous support remains to support the gingival margin and prevent marginal recession in an apical direction.

When the distance between the buccal border of the buccal plate and the implant-abutment junction is less than 2 mm (Fig 6-5c), osseous support will be resorbed through its entire thickness (Fig 6-5d). The osseous crest will, accordingly, migrate in an apical direction to achieve the thickness needed for adequate nutrition, and the gingiva it supports will follow in a similar apical recession.

In the coronoapical direction, the implant-abutment junction will be at varying distances below the osseous crest, depending on how deeply the implant has been positioned. The further subcrestally the junction lies, the more bone will resorb, although the amount of bone loss below the implant-abutment junction seems to be constant.

However, as yet, no correlation has been established between the subcrestal position of the junction and the vertical resorption of the buccal plate. Therefore, it is difficult to precisely estimate how much bone loss will result from a given subcrestal positioning.

To summarize:

For a papilla to be present between two implants:

- The interimplant distance must be 3.0 mm or more.
- The distance between the peak of the crest and the most apical edge of the contact point between crowns must be less than 4.0 mm.

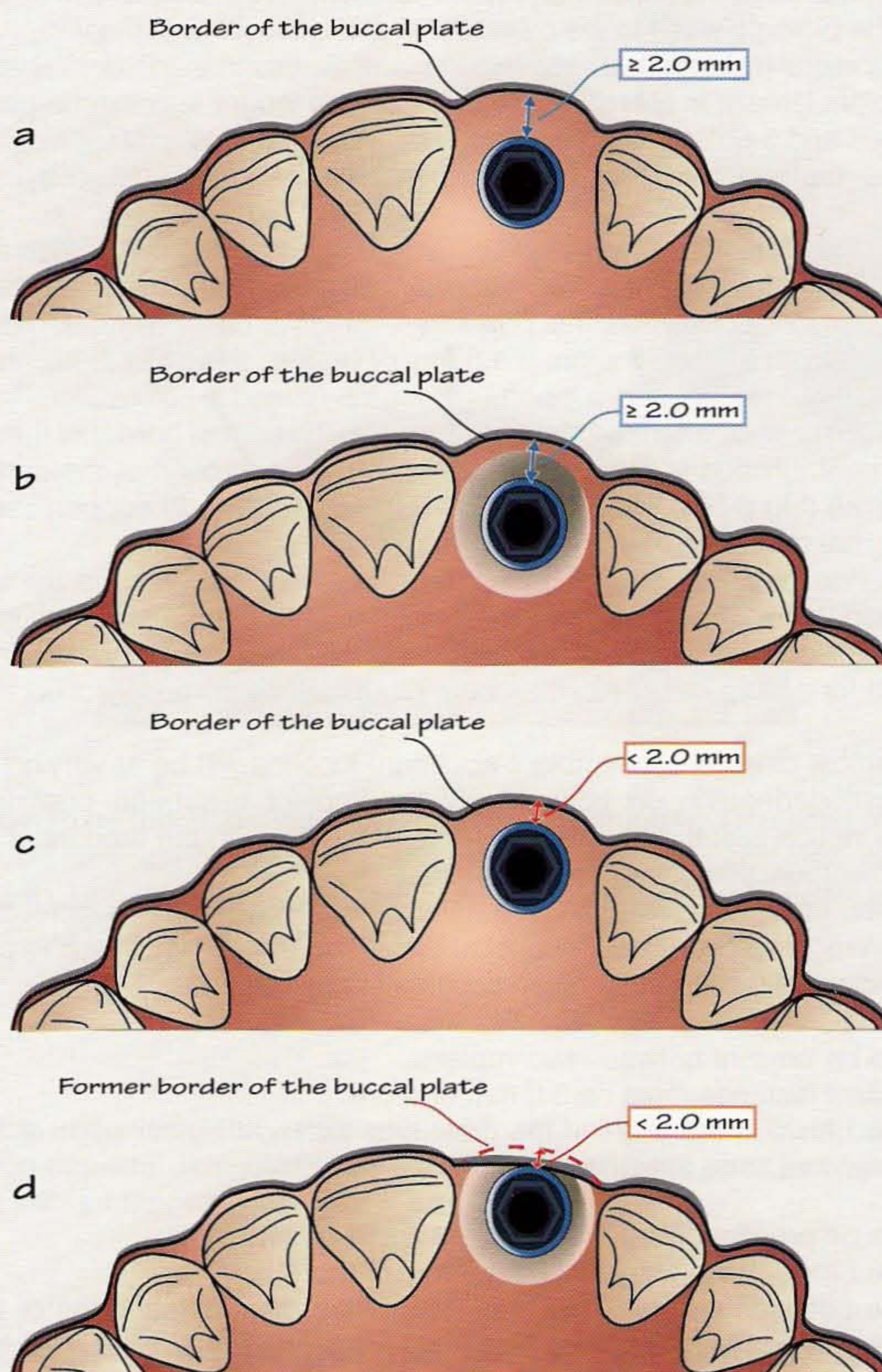
For a papilla to be present between an implant and a natural tooth:

- The distance between the two must be 1.5 mm or more.
- The distance between the peak of the crest and the most apical edge of the contact point between crowns must be 5.0 mm or less.

A way to bypass these strict rules of implant positioning, the concept of *platform switching*, will be discussed later in the chapter. The technique involves modifying the abutment size in relation to the implant neck.

▼ Manipulation of Abutments

Abutment manipulation, that is, repeated screwing and unscrewing, can also have an effect on the final level of the bone crest and, consequently, on support of soft tissues. When a prosthetic abutment is affixed immediately after implant placement, the soft tissues reposition themselves around the abutment and form a mucoepithelial seal. Repeated screwing and unscrewing of the abutment disrupt the attachment; it recedes apically toward the nearest stable zone, which is the implant neck⁹ (see Fig 5-5). In accordance with the principle of conservation of the biologic width, described in chapter 5, the first contact of bone with the implant is also displaced apically.



▲ Fig 6-5 Effect of the buccopalatal distance between the border of the cortical plate and the implant-abutment junction. (a) At the time of implant placement, the distance between the external border of buccal plate and the implant-abutment junction is greater than 2.0 mm. (b) After the implant has been functioning for several months in this position, a 1.5-mm craterlike recession has formed around the implant-abutment junction but has not reached the external border of buccal bone. The marginal gingiva still receives adequate support from the residual buccal plate. (c) At the time of implant placement, the distance between the external border of buccal bone and the implant-abutment junction is less than 2.0 mm. (d) After the implant has been functioning for several months in this position, the crater that has formed around the implant-abutment junction extends 1.0 to 1.5 mm. The external border of the buccal plate is resorbed, resulting in apical resorption of the bone. The lack of bony support causes marginal recession that leaves the prosthetic abutment exposed.

If the buccal plate is less than 2 mm thick, its entire buccal aspect will be resorbed in an apical direction. The soft tissues, having lost their osseous support, will in turn migrate apically, causing unsightly exposure of the metallic border of the crown-abutment junction. In animal experimentation, it has been shown that repeated unscrewing can also trigger supplemental bone loss of 0.7 mm, which is accompanied by gingival recession of 1.5 mm.⁹

In patients with a thin periodontal biotype, clinicians would be well advised to place a “final” abutment to receive the provisional prosthesis; this abutment is not unscrewed.¹⁰ It supports not only the provisional prosthesis but also the final restoration. If gingival recession does occur during the provisional phase, the prosthodontist reshapes the abutment in the mouth without removing it, to avoid disrupting the mucoepithelial attachment. The abutment should be unscrewed only if it has to be replaced or reshaped in the laboratory. A case illustrating this concept is shown in Fig 6-6.

▼ Determination of the Optimum Number of Implants

In the partially edentulous patient, clinicians may have to use fewer implants than they would otherwise have chosen, in order to respect the minimum desirable distance between implants and teeth or between implants. A compromise between esthetic demands and biomechanical requirements must be found.

This situation can occur when four maxillary anterior teeth have been lost. Instead of placing one implant to replace each tooth, it may be advisable to use only three implants and a pontic (see Figs 5-15c and 5-15d).

▼ Platform Switching

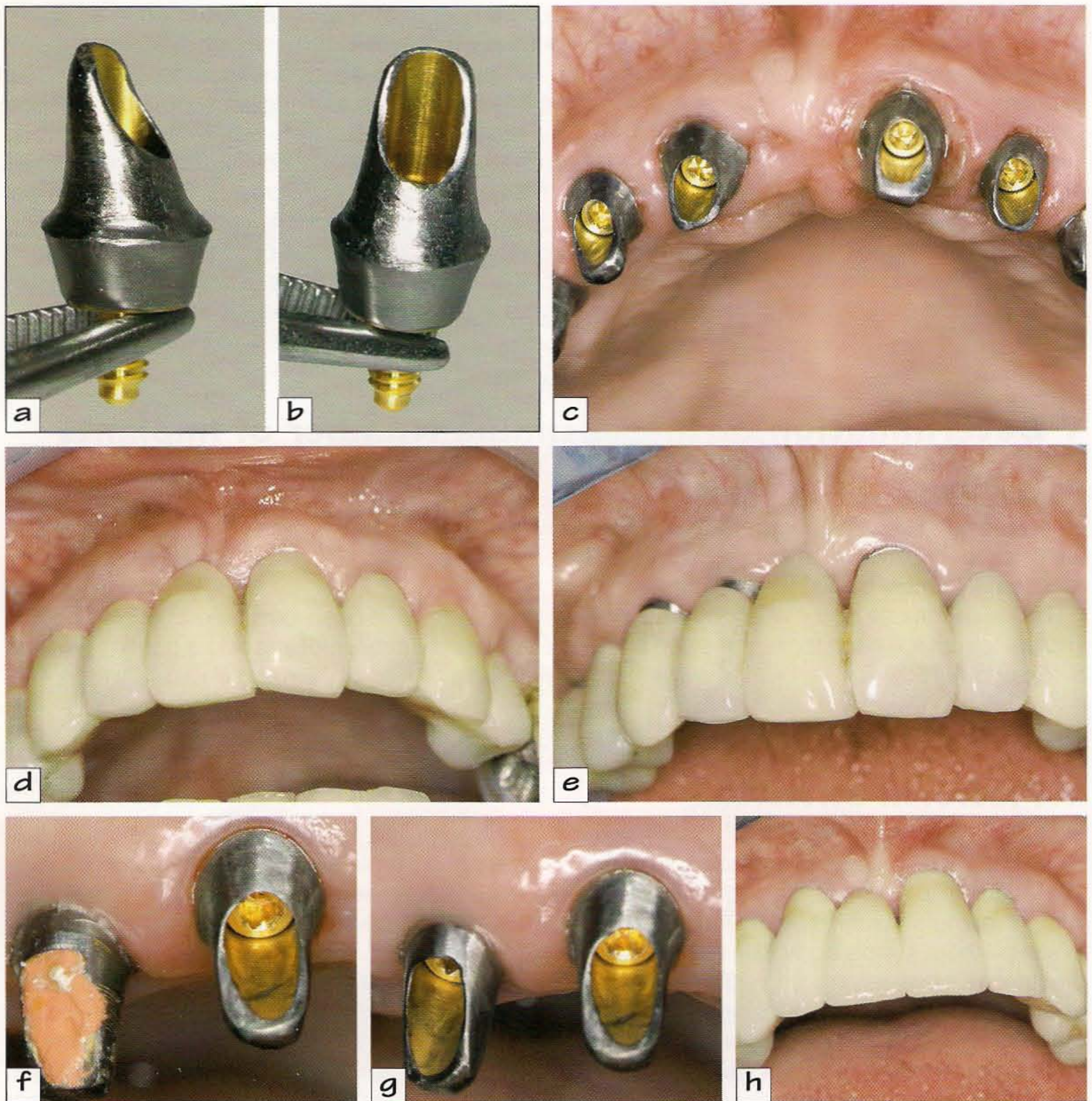
Platform switching consists of placing a smaller abutment in an implant neck of a given size (Fig 6-7). The effect of platform switching on hard tissues was discovered serendipitously.¹¹ In 1991, an implant manufacturer (Biomet 3i) launched large-diameter, 5.00- and 6.00-mm implants on the market without supplying abutments of corresponding diameters. In the posterior quadrant, some prostheses were relying on a combination of 3.75-mm and 5.00- or 6.00-mm implants, but all abutments were similar in diameter, fitting the 3.75-mm implant. Vertical resorption developed around the standard-sized implants as expected; resorption reached the first thread, as evidenced on radiographs. The crestal bone around the larger implants, however, remained at its original level; the anticipated resorption had not taken place. For a long time, this phenomenon was neither interpreted nor exploited.

This “simple” discrepancy between the abutment diameter and the diameter of the implant platform seems to have the property of preventing the occurrence of both the apical and the horizontal bone resorption usually observed around this type of structure.^{11–14} In turn, this platform-switching adjustment might allow more predictability in defining the final position of soft tissues around implants. This might force reevaluation of the required minimum distances between implants and adjacent dental units (see Fig 5-6).

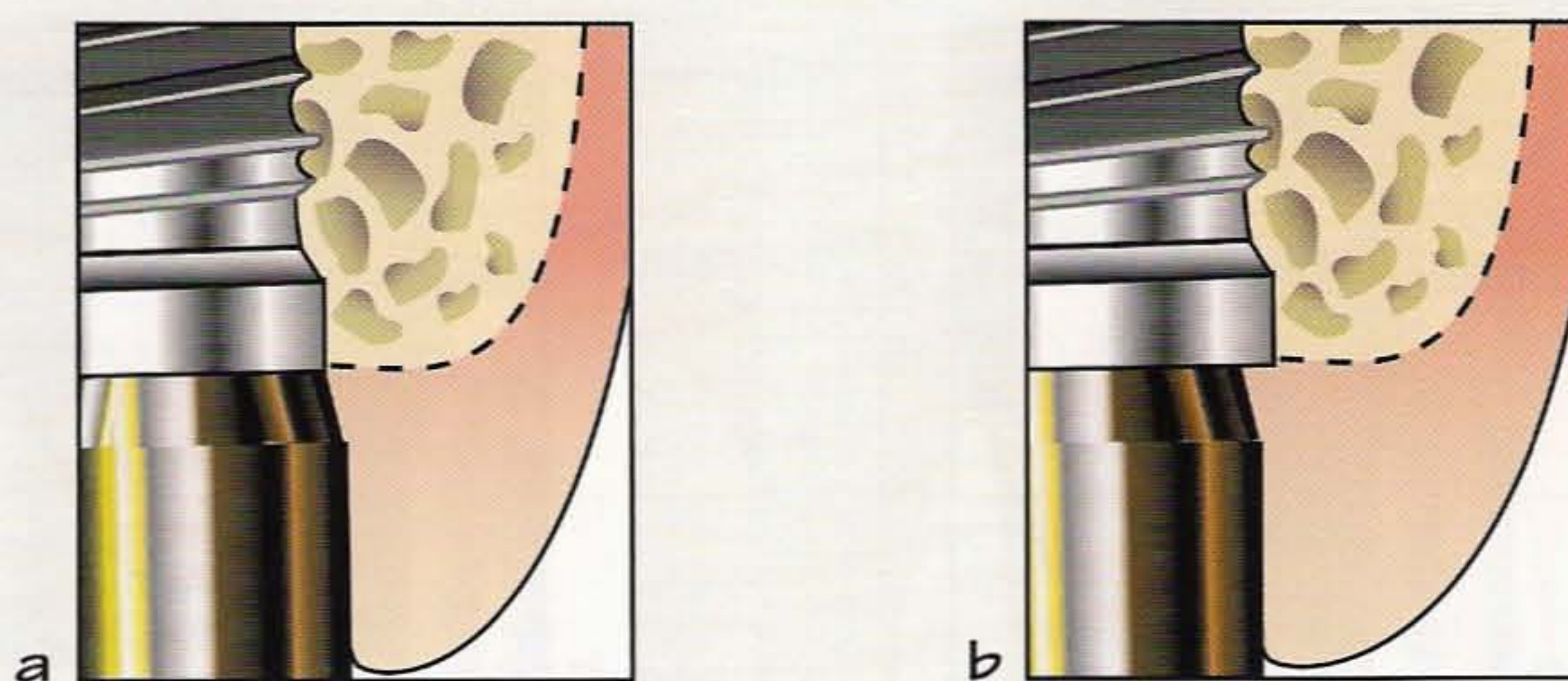
Comparison of implants placed with and without platform switching has provided radiographic evidence of the success of this technique (Fig 6-8). Around implants that have been platform switched, only a slight amount of vertical and horizontal bone resorption takes place (see Fig 6-8b). Around implants that have not been platform switched, vertical resorption reaches the first thread and horizontal bone loss extends as usually recorded (see Fig 6-8d).

Theories on the platform-switching phenomenon

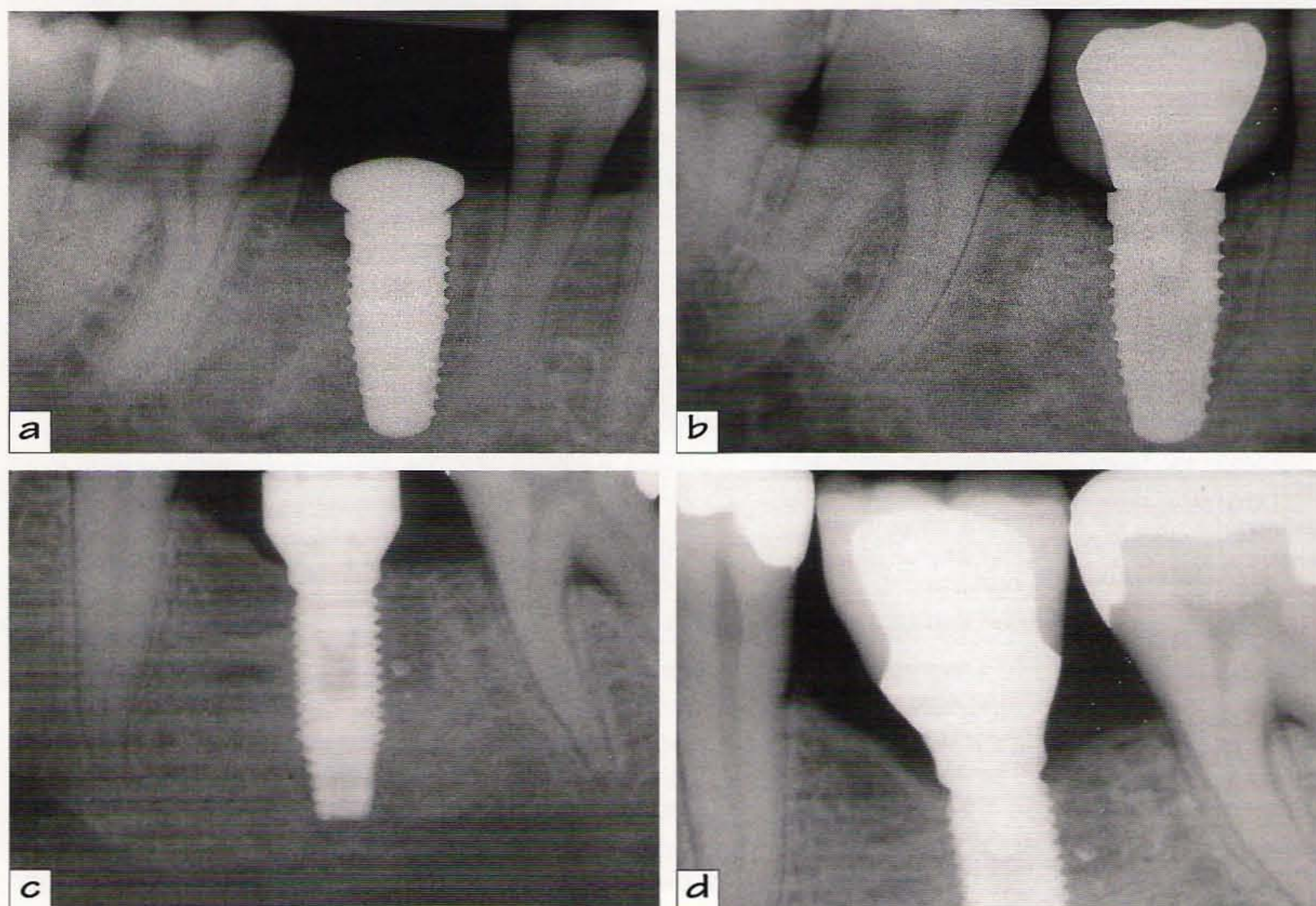
Interpretation of this phenomenon is difficult because there are still several opposing theories to explain the vertical and horizontal bone loss around the classic abutment–implant neck configuration. To formulate possible explanations as to why bone loss does not occur at platform-switched implants, it is necessary to discuss three theories as to why it does occur at traditional connections:



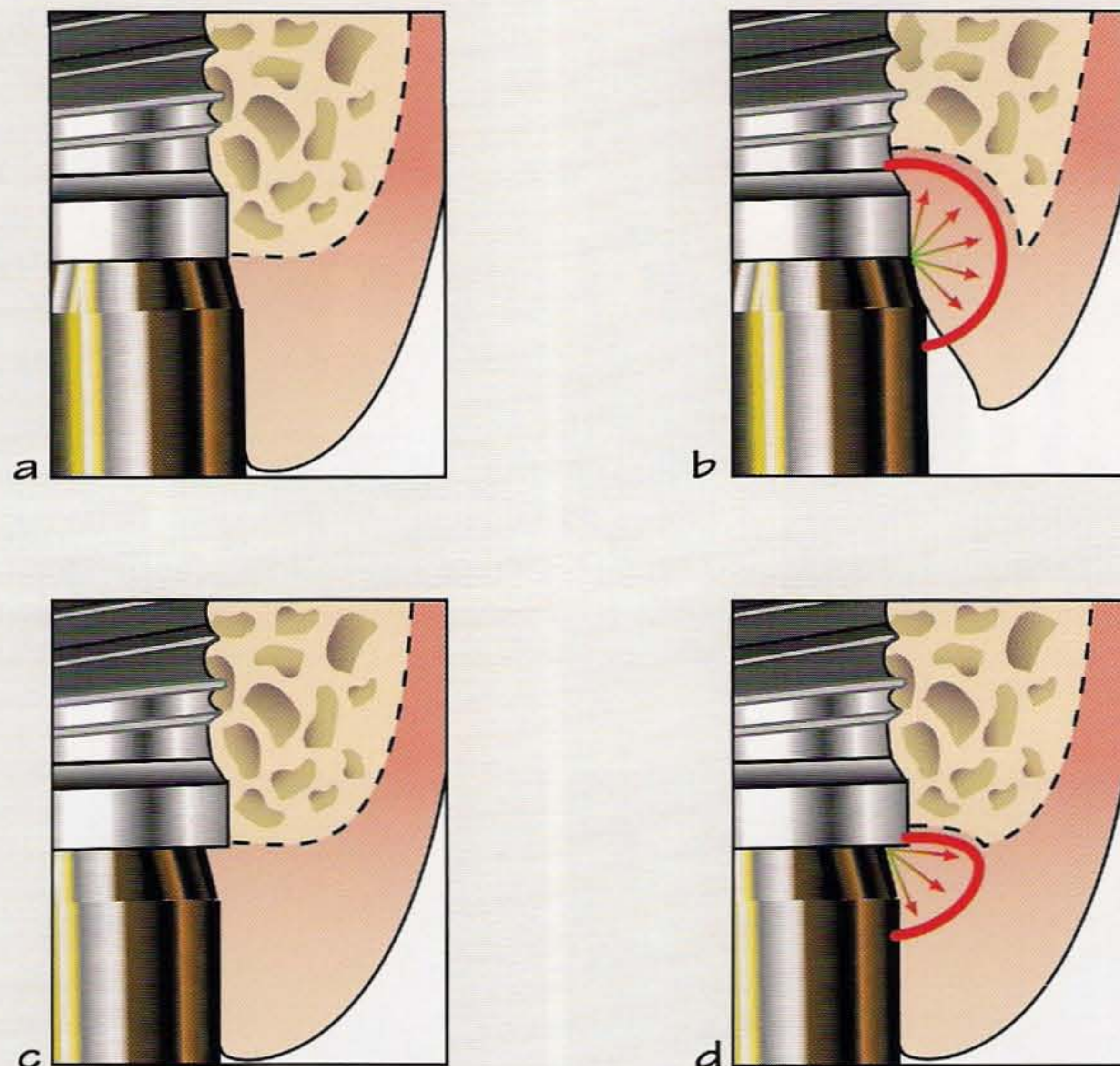
▲ **Fig 6-6** Restoration of an edentulous maxilla for a patient with a thin periodontal biotype and a high smile line. (a and b) Laboratory-prepared "final" titanium abutments. These abutments are intended to receive both the provisional prosthesis and the final prosthesis, without the need for removal. (c) Final abutments placed to support the provisional prosthesis. (d) Immediately loaded provisional prosthesis at the 1-week recall examination. The prosthesis shows excellent adaptation of its cervical margins to the gingival border. (e) Provisional prosthesis after 6 months of loading. Gingival recession has appeared around some of the abutments. (f) Abutment reshaping in the mouth. (g) Final appearance of the reshaped abutments. (h) Final prosthesis in place on the adjusted abutments. (Prosthesis by Dr S. Molloy.)



▲ **Fig 6-7** Concept of platform switching. (a) Traditional edge-to-edge relationship of abutment and implant neck. The dimensions of the two elements coincide. (b) Relationship of abutment and implant neck in the platform-switching concept. The abutment is narrower than the implant neck.

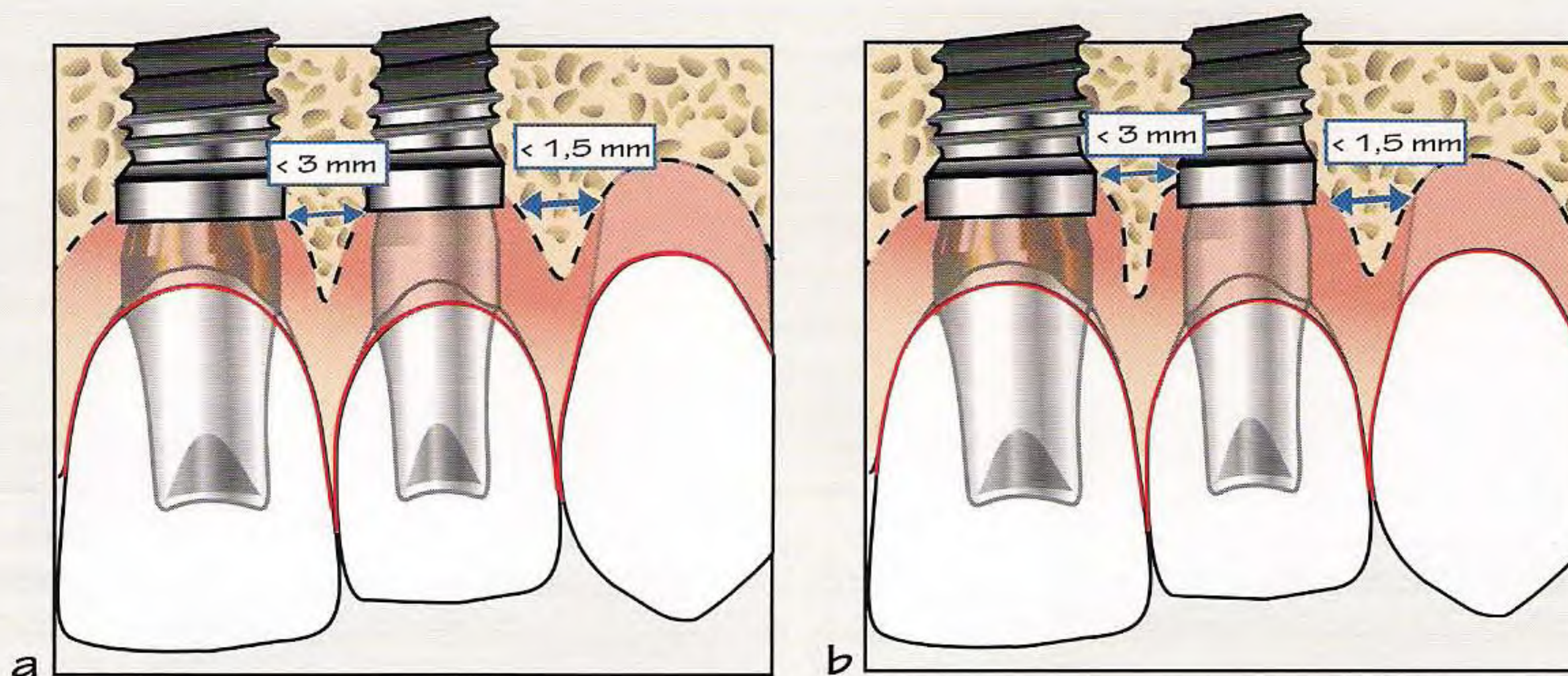


▲ **Fig 6-8** Effect of platform switching on hard tissue resorption. (a) Postoperative radiograph of platform switching. The diameter of the healing abutment is smaller than that of the implant. (b) Radiograph of the implant carrying a crown prepared in accordance with the principle of platform switching. Horizontal and vertical resorption are minimal, not reaching the first thread of the implant. (c) Postoperative radiograph of traditional abutment-implant neck placement. The diameters of the abutment and the implant neck are identical. (d) Radiograph of the implant carrying a crown with an abutment of identical dimension. The vertical resorption reaches the first thread as expected; horizontal bone loss is also present.



▲ **Fig 6-9** Hypothesis describing the presence of an inflammatory zone to explain the different types of bone resorption affecting implants with and without platform switching. (a) Implant placement level with the crest, without platform switching. (b) Diffusion of inflammation around the traditional abutment-implant junction. The trajectory of the chronic inflammation takes the form of a semisphere 1.0 to 1.5 mm in radius, leading to vertical and horizontal bone resorption. (c) Implant placement level with the crest, with platform switching. (d) Limited diffusion of chronic inflammation around the abutment-implant junction, showing how platform switching has contained it. The trajectory of the chronic inflammation is blocked from diffusing apically by the head of the implant. The inflammatory path is detoured coronally, limiting horizontal bone resorption.

1. According to one theory, when the dimensions of the implant neck and abutment match, resorption proceeds vertically to the first thread because of conservation of the biologic width.^{15,16} With platform switching, the biologic width forms along the off-set connection between abutment and implant neck. Projected on a vertical axis, the corresponding apical extent of resorption would be more limited and would not reach the first thread.
2. Another theory holds that the horizontal and vertical resorption observed at the traditional implant-abutment junction results from the presence of chronic infection^{17,18} (Fig 6-9). The existence of this infection, which is limited to connective tissue, has long been known and has been demonstrated in animal experiments.¹⁹ The bacteria causing this inflammation originate from the interior of the implant after having migrated along the interstitial spaces of the screw access holes or along the abutments. There, they multiply and pass across the nonhermetic implant-abutment interface. The inflammation diffuses into a semispheric pattern with a radius of 1.0 to 1.5 mm (Fig 6-9b). Vertically, it translates into bone resorption to the level of the first thread and horizontally it triggers resorption away from the bone-implant interface. The combination of both results in craterlike bone loss (see Figs 6-8d and 6-9b). According to this



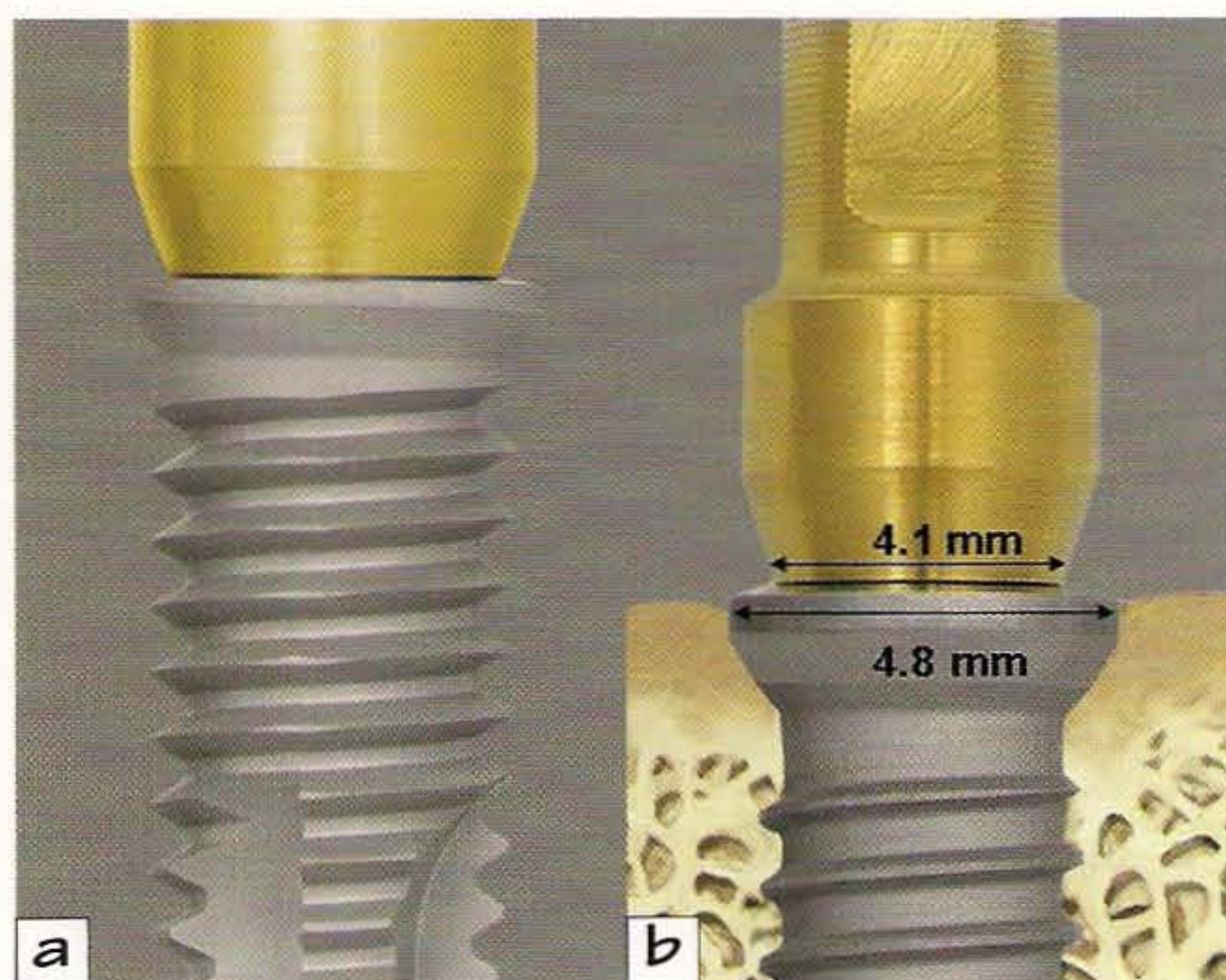
▲ Fig 6-10 Possible simplification of platform-switching related to the minimum distances to keep between implants and adjacent units. (a) Implant placement level with the crest. Immediately after placement, the distance between implants is less than 3.0 mm; between the implant and the adjacent tooth, the distance is less than 1.5 mm. (b) Bone response to platform switching. Although the rules of minimum distances between adjacent units have been disregarded, the limited bone loss in the vertical and horizontal directions should prevent the interimplant crest as well as the crest between the implant and the adjacent tooth from collapsing. The papillae and the marginal gingiva should receive their required support and avoid apical recession.

theory, when platform switching with lateral off-set of the abutment is performed, the thrust of the chronic inflammation does not take the form of a 1.0- to 1.5-mm semisphere but is blocked from diffusing apically by the implant head. Instead, the inflammatory path is detoured horizontally or coronally (see Fig 6-9d). This change in trajectory protects the bone from apical extension of the bone loss and causes only a minor amount of horizontal resorption. Hence, the osseous level is conserved and the soft tissues of the marginal gingiva and the papillae benefit from improved support.

3. In the view of other authors, the resorption observed around implants that have not been platform switched is due to the chronic insult of micromovements of the implant-abutment junction.^{20,21} When platform switching is introduced, micromovements no longer occur in the immediate proximity of bone. Bone no longer needs to withdraw from the mechanical insult by undergoing substantial resorption and can remain in close contact with the implant neck.

Whatever the real reasons for its efficacy in limiting bone resorption, platform switching opens new prospects:

- It should make possible a reduction in the mandatory minimum distance between implants and other dental units (Fig 6-10).
- It should relax the rules of implant positioning.
- It should simplify the management of esthetics.
- For immediate-loading purposes, it should permit placement of more implants to conform to the biomechanical criteria without compromising esthetic requirements.



◀ **Fig 6-11** Prevail implant. (a) Design of a Prevail implant. (b) Placement of a Prevail implant, level with the crest.

▼ Prevail Implant: Built-in Platform Switching

Characteristics

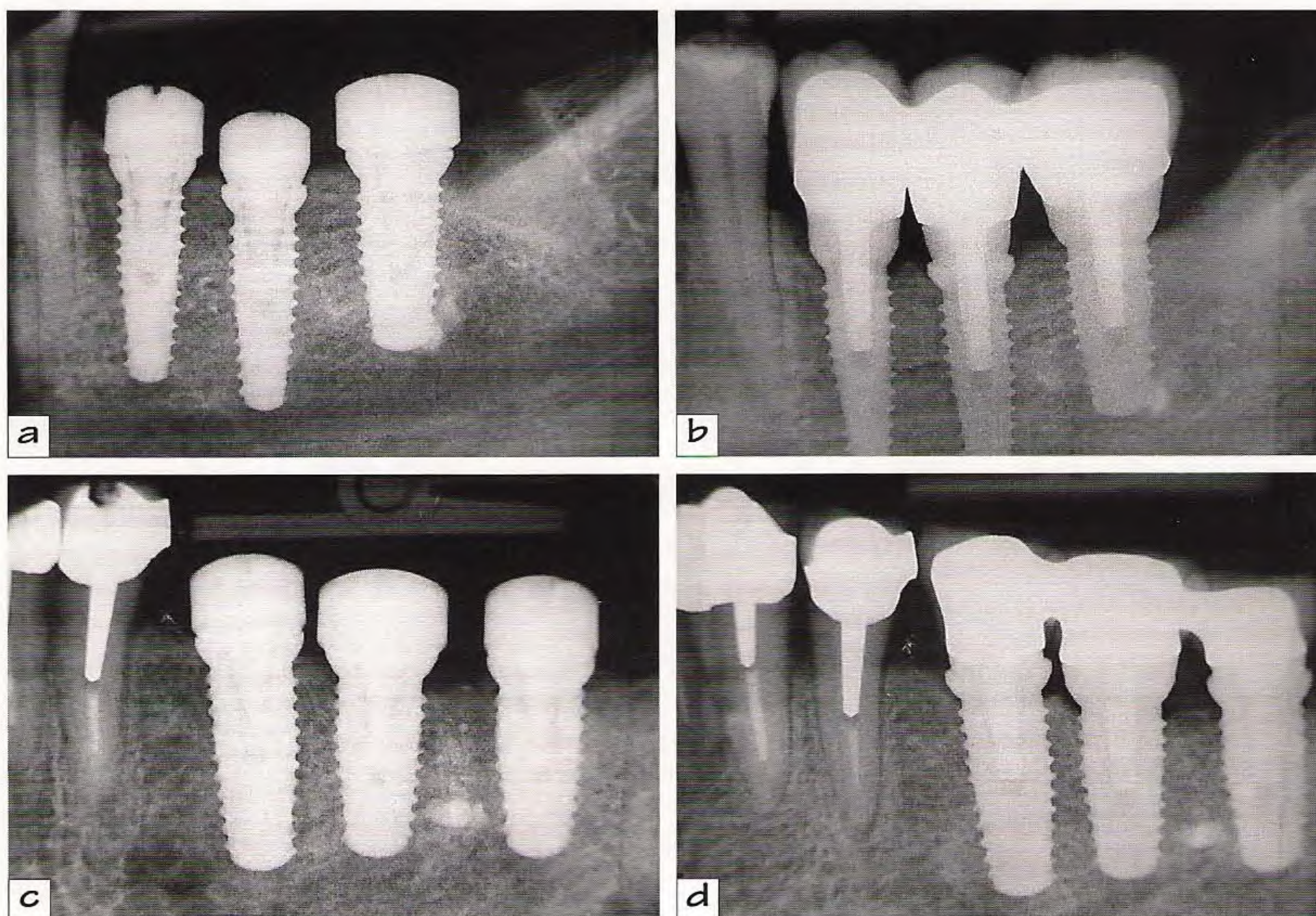
After the platform-switching concept was identified, an implant incorporating its principles was designed to respond more effectively to esthetic requirements. Recently introduced to the market under the trade name Prevail (Biomet 3i), the implant is claimed to offer a variety of improvements over the standard implant model (Fig 6-11). All the modifications are aimed at simultaneously satisfying the needs of immediate loading and acceptable esthetics:

- For platform-switching needs, the implant has a widened platform similar to that available with the XP implant (Biomet 3i) and a color-coded abutment, whose diameter is smaller by 0.70 mm than the diameter of the implant neck. This size differential provides a 0.35-mm off-set at the implant-abutment junction.
- Prevail has a widened platform instead of parallel walls so that the primary stability can be improved by having the platform rest on the bone crest. Furthermore, the implant can circumscribe the socket more effectively when it is placed immediately after tooth extraction, and the widened platform provides better seating for large crowns.
- To retain the bony crest at the pre-implant placement level, the Osseotite surface treatment (Biomet 3i) and the bioactive NanoTite surface (Biomet 3i) are applied when Prevail is used, from the apex to the neck of the implant. This replaces the hybrid Osseotite, where the three most cervical threads were left machined and unetched.

Use of the Prevail implant increases the probability that the vertical and horizontal bone level will remain unchanged, close to the original level at implant placement (Figs 6-12a and 6-12b). However, this result cannot not be guaranteed, because bone level can be adversely affected by many factors, not all of which can be predicted in advance (Figs 6-12c and 6-12d). Poor management of any parameter can counterbalance the beneficial effects conferred by the new geometry of the implant.

Advantages

The clinician may question the advantages derived from integrating the concept of platform switching into implant design, when the principle can so easily be applied to standard implants



▲ **Fig 6-12** Reaction of the crestal bone to the placement of a Prevail implant. (a) Postoperative radiograph of a Prevail implant placed in the posterior region of the mandible. The Prevail implant is in the middle. The others are XP implants, which were used as controls. (b) Radiograph taken after placement of the final prosthesis, 5 months after the surgical procedure. The bone around the Prevail implant has remained at its original level but vertical resorption has taken place around the XP implants. (c) Postoperative radiograph of a Prevail implant placed in the posterior region of the mandible. The Prevail implant is the most mesial, and the two XP control implants are distal to it. (d) Radiograph taken 4 months after surgery, at the time of the placement of the final prosthesis. Vertical resorption is found around all three implants. The cause of the bone resorption around the Prevail implant has not been identified.

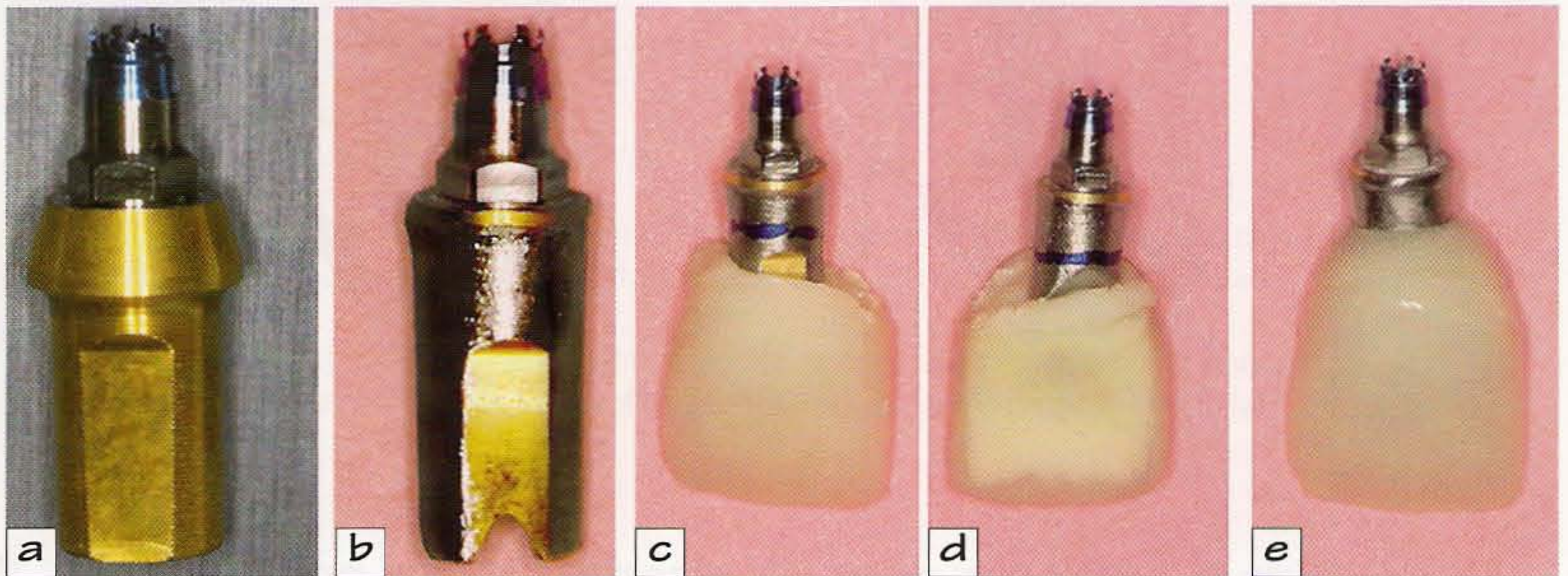
simply by placing an abutment of smaller diameter. The advantages can be summarized in this way:

- The concept of platform switching can be applied to implants 3.25 mm in diameter as well as those of 4.00 mm. With standard implants, only 5.00- and 6.00-mm-diameter implants can receive abutments that are smaller. This advantage alone should be a determining consideration.
- The prosthodontist may forget that an implant was intended to receive a smaller abutment. When platform switching is incorporated in the implant design, the prosthodontist will receive the matching smaller color-coded abutments with the implant. This eliminates any possibility of mistakes from the outset.





◀ **Fig 6-15** Zirconia (zirconium oxide) abutment (left); titanium abutment covered with a yellow titanium nitride layer (right).



▲ **Fig 6-16** Changes in the size of the prosthetic abutment to encourage proliferation of gingival tissue. (a) Standard titanium abutment. (b) Abutment diameter reduced to allow soft tissue proliferation. (c) Construction of the provisional crown (buccal view). The blue mark on the abutment indicates the apical border of the crown. (d) Construction of the provisional crown (lingual view). The blue mark on the abutment indicates the apical limit of the crown. (e) Finished provisional crown. It has been shaped to occupy only part of the available space so that gingival tissue can grow in the open area. (Prosthesis by Dr P. Raygot and G. Fournier.)

These new approaches remain experimental and must be carefully documented. Still, the few cases already treated in this way seem to show that leaving space for soft tissues to proliferate evokes a favorable response.²³

Provisional versus final abutment

In most cases, the abutments used for provisional prostheses are themselves provisional, so they are unscrewed when the final restoration is to be placed. The abutment is unscrewed when an impression is taken for the final prosthesis and again when the prosthesis is placed.

The manipulation of the abutment that has been left in position since the time of surgery is likely to disrupt the mucoepithelial attachment and provoke it to migrate apically toward the implant neck.

In turn, following the principle of conservation of the biologic width, apical bone migration will result, followed by gingival recession. For patients with a thin periodontal biotype, the conservation of the biologic width precipitates an additional vertical resorption of bone, which is followed by even more gingival recession. This could lead to unacceptable esthetics in the anterior maxilla.

Therefore, when esthetic considerations prevail, prosthodontists should install final abutments after surgery (see Fig 6-6). These abutments, made of titanium or zirconia, should not be unscrewed, even during preparation of the final prosthesis. This should maintain the height of the mucoepithelial attachment on the abutment, providing the best esthetic result.

If soft tissues do migrate during the healing period, leading to gingival recession, the prosthodontist must make appropriate adjustments of the abutments by reshaping them in the mouth without unscrewing them (see Fig 6-6). After recontouring is completed, an impression is taken of the newly shaped abutments. The new impression is sent to the laboratory for construction of the final prosthesis.

Provisional prosthesis

Sometimes circumstances dictate the need for the presence of papillae even throughout the provisional phase. To respond to this need, prosthodontists might be tempted to move the contact point between crowns apically so that papillae will appear to completely fill the available space.

This solution is not a good idea because one of the functions of the provisional prosthesis is to encourage the formation of papillae and to organize the emergence profile of soft tissues immediately after the surgery. Moving the contact point apically between two crowns will crowd adjacent soft tissues and prevent them from achieving their full growth potential. This is a special concern with papillae between an implant and a natural tooth, where the phenomenon of “creeping papilla” (creeping augmentation of the length of the papilla with time) occurs.²⁴ However, prosthodontists are justified in adjusting the level of the contact points in final prostheses to provide the illusion of total integrity of the papillae, which, by this time, have exercised their full growth potential.

Where restorations are placed immediately after tooth extraction, the existing papilla had been stabilized by the affected natural tooth. Placement of an implant is inevitably followed by the loss of at least some bone. The papilla formed around the implant will, of necessity, be smaller than the one it replaces. The solution is for the prosthodontist to construct the provisional crown with a contact point identical to that of the extracted tooth. In this way, papillary growth will not be hindered by a contact point that is too close to the gingiva.

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Chapter **7**

SELECTION OF SCREW-RETAINED OR CEMENTED PROVISIONAL PROSTHESES

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In most immediate-loading protocols, edentulous areas are restored with two prostheses, a provisional and a final. For both phases, the prosthodontist must decide whether the prosthesis should be screw retained or cemented. In some cases, the retention mode for the prosthesis is obvious, as it is for the hybrid fixed-detachable prosthesis (ad modum Brånemark) used to restore the edentulous mandible. On the other hand, for other restorations, such as single crowns in the anterior maxilla, either technique might be acceptable.

The provisional and final prostheses do not have to be affixed to implants in the same way. Rather, the retention mode depends on specific individual requirements. Figure 7-1 presents the range of possibilities. For the traditional delayed-loading protocols, the type of fixation is determined by the amount of space available for the prosthesis, occlusion, esthetic requirements, and the prosthodontist's personal preference. These rules apply to immediate loading as well, in addition to specific requirements that will be discussed later.

▼ **Screw-Retained Provisional Prostheses**

The provisional prosthesis is either screwed directly into the implant or screwed into a provisional abutment that is screwed into the implant.

Advantages

- The clinician can easily remove the prosthesis without any mechanical demand on the implant.
- The clinician can assess implant stability without disturbing the progress of osseointegration.
- Screw retention avoids the risk that excess cement will remain between the implant and the gingiva—or even worse in the extraction socket—and compromise implant osseointegration. Screw retention is particularly indicated when implants are placed in extraction sockets.
- In cases where many implants have been placed, the clinician can easily detect the absence of passive seating.

Disadvantages

- The shape of the occlusal surface is altered by the screw access path.
- The screw access path weakens the mechanical resistance of the occlusal material, enhancing the risk of coronal fracture.
- For incisors, the implant axis must be palatally inclined with respect to the incisal edge. This limits the number of instances where screw retention can be selected.
- The process of screwing in a complete prosthesis that is supported by a number of implants increases the chair time needed for placement and removal of the prosthesis.
- The small screws may loosen or fracture.

Indications

Screw retention is the solution of choice for provisional prostheses in the following cases:

- Restoration of a completely edentulous mandible
- Restoration of a completely edentulous maxilla by the means of the conversion prosthesis (removable denture converted to a fixed prosthesis)
- Restoration of a partially edentulous anterior mandible

Screw retention can be considered for a provisional prosthesis replacing a single tooth or a few teeth in the anterior maxilla, provided that the angulation of the implants is palatal with regard to the incisal edges. If the implant is angled too far labially, esthetics might be compromised and cementation is a more practical solution.

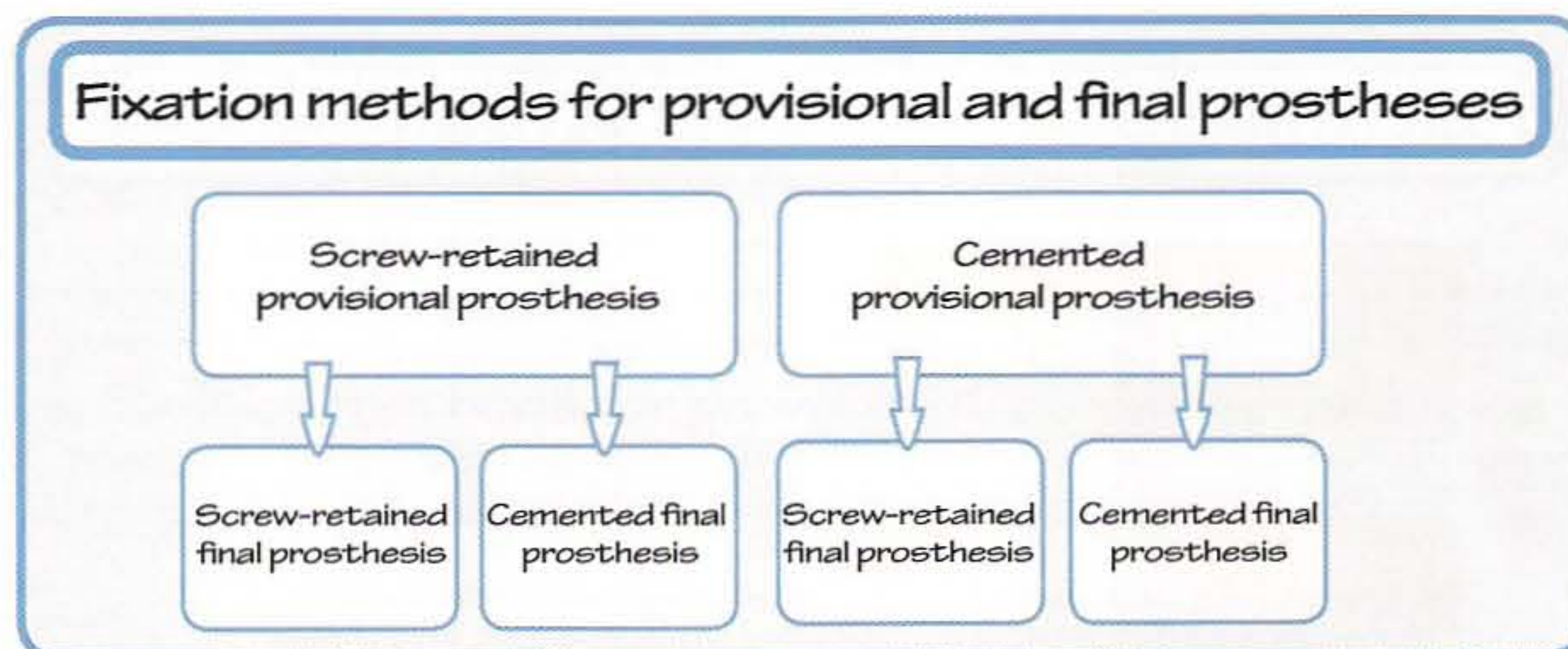
Screw retention of a provisional prosthesis is not indicated for a restoration of partial edentulism in posterior areas, because high forces are exerted on the fixation screws.

▼ Cemented Provisional Prostheses

The prosthesis is attached to abutments with temporary cement, while the abutments are screw retained in the implants.

Advantages

- The anatomy of the occlusal surface is preserved.
- The buccolingual angulation is more readily regulated.
- When a number of implants are involved, the clinician can more easily place and remove the prosthesis.
- Cementation allows placement of final abutments instead of provisional abutments, which is especially desirable in patients with a thin periodontal biotype or when esthetics is a concern. Final abutments are not unscrewed when the final prosthesis is being prepared. If necessary, they are reshaped in the mouth, and an impression is made and sent to the laboratory.



▲ **Fig 7-1a** Range of possibilities for fixation of both provisional and final prostheses. The choice of fixation mode for the provisional prosthesis does not prevent the use of a different retention mode for the final prosthesis if it is more appropriate. Four possible combinations are therefore available: a screw-retained or a cemented provisional prosthesis succeeded by a screw-retained or a cemented final prosthesis.

Disadvantages

- Excess cement may irritate surrounding soft tissue and cause inflammation or even interfere with the process of osseointegration. This risk is most pronounced in extraction sites.
- Cementation of a provisional prosthesis is not indicated when placement of the implants is deeply subcrestal.
- Cementation does not permit the clinician to verify implant stability, because removal of cemented prostheses might require a level of force that would compromise the progress of osseointegration.
- Cementation has to be performed with some speed to conform to the setting time of the material.
- The prosthesis may debond.

Indications

Cementation is the solution of choice for a provisional prosthesis in the following cases:

- Restoration of a completely edentulous maxilla, especially where the final abutments are placed immediately, as is common for patients with a thin periodontal biotype
- Restoration of partial edentulism in posterior regions

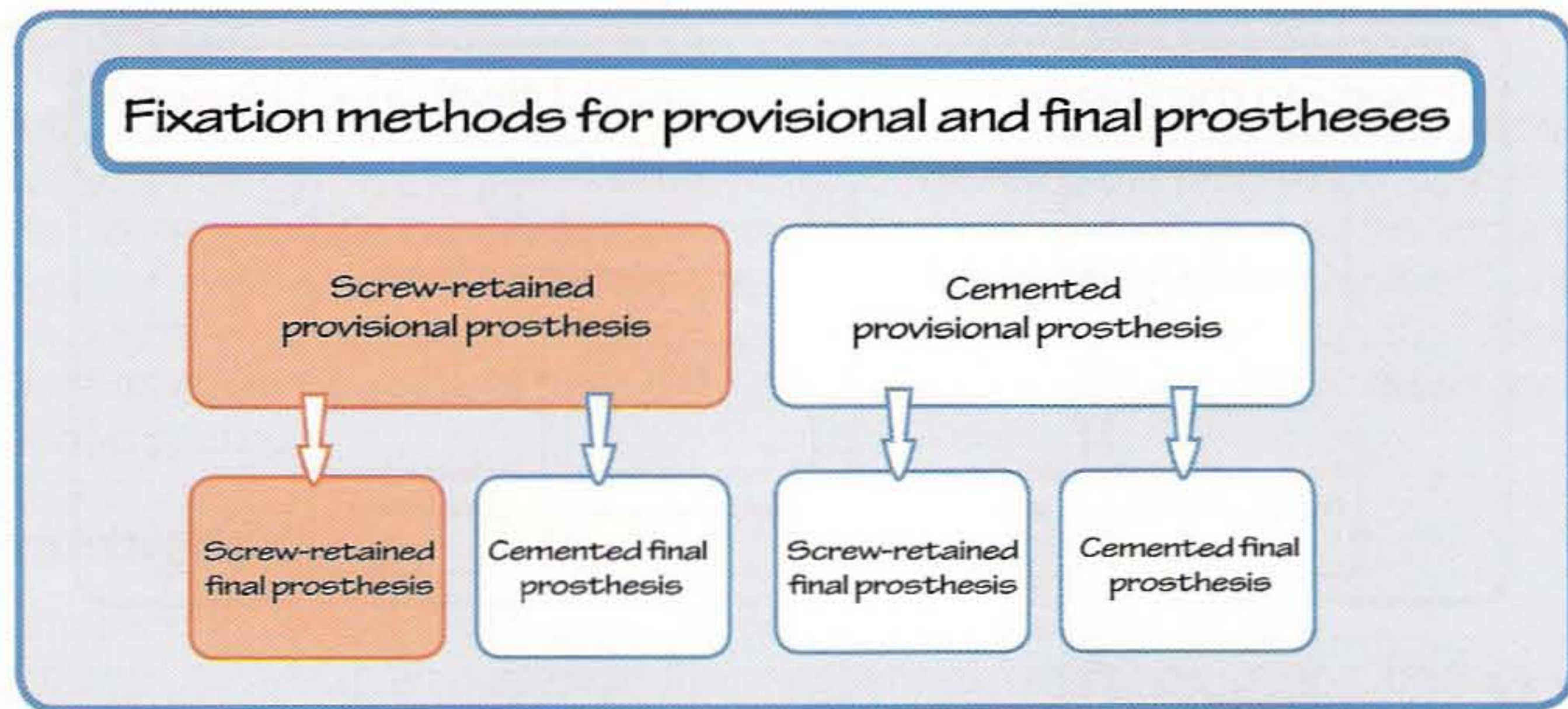
Cementation can be considered for a restoration of only one or a few missing maxillary anterior teeth, because esthetics and emergence profile are more easily managed with this method.

Cementation of a provisional prosthesis is not indicated for the following cases:

- Treatment of an edentulous mandible when a hybrid prosthesis is indicated
- Replacement of missing mandibular anterior teeth when the available mesiodistal space is limited

▼ Combination of Retention Methods for the Provisional and Final Prostheses

Theoretically, it is possible to select any combination of fixation type for the provisional and the final prostheses (see Fig 7-1a), as long the choices conform to the logic of the treatment plan.

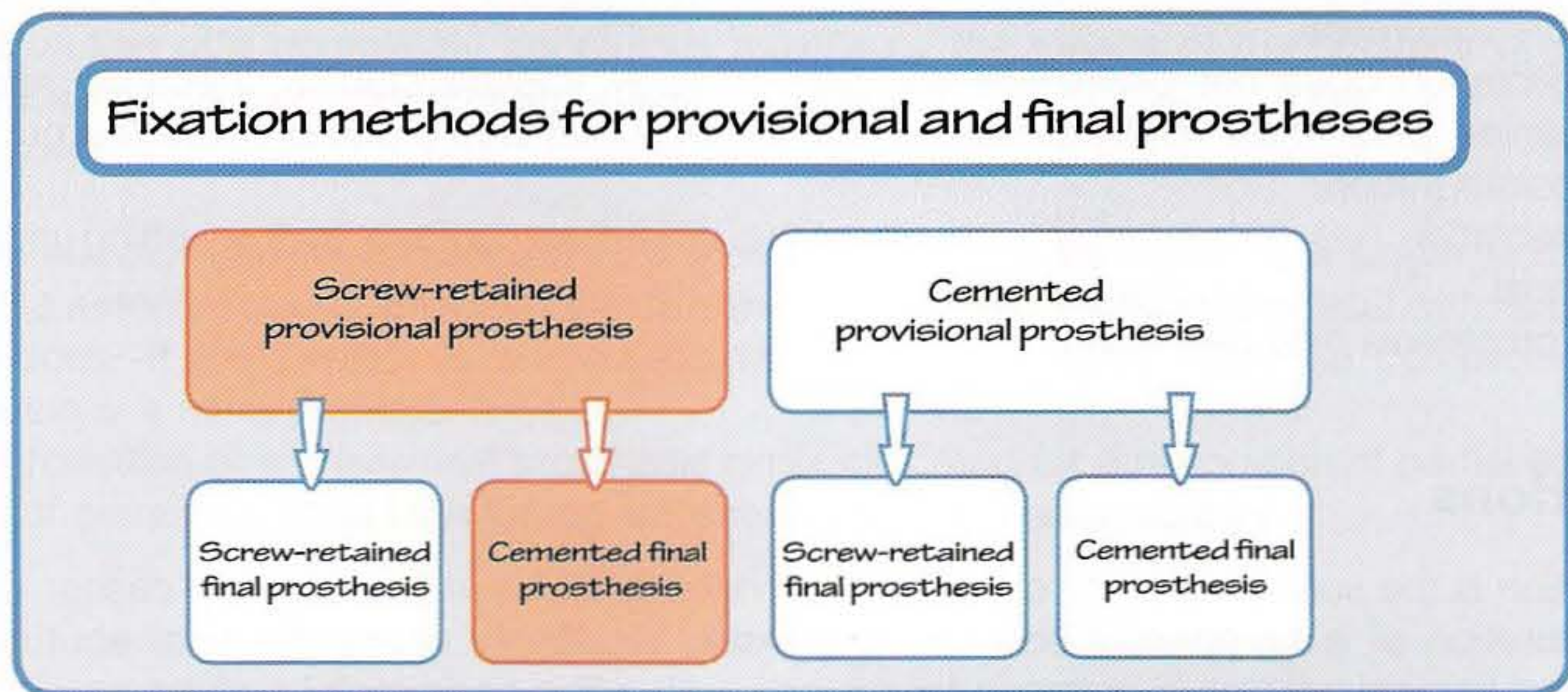


▲ **Fig 7-1b** Screw-retained provisional and final prostheses.

Screw-retained provisional and final prostheses

This combination (Fig 7-1b) is appropriate when:

- An edentulous mandible is rehabilitated with a hybrid prosthesis.
- The space available is insufficient to accommodate a 4-mm abutment.
- Limited space is available for the prosthetic teeth.



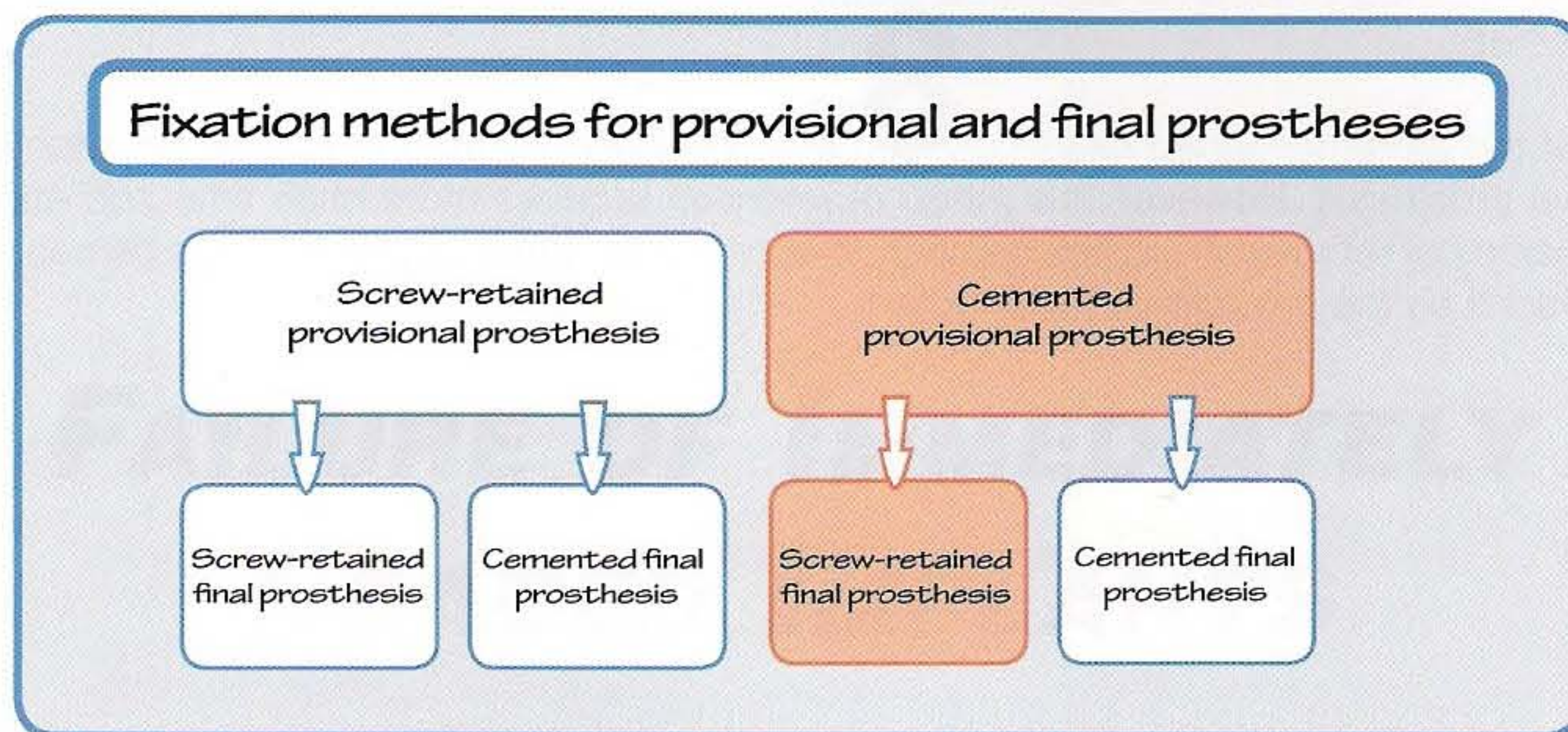
▲ **Fig 7-1c** Screw-retained provisional prosthesis and cemented final prosthesis.

Screw-retained provisional prosthesis and cemented final prosthesis

This combination (Fig 7-1c) is appropriate when:

- In the edentulous mandible, the provisional prosthesis will be a hybrid prosthesis supported by some of the placed implants and the final prosthesis will be a cemented prosthesis supported by all the implants.
- The practitioner wants to avoid diffusion of excess cement in newly sutured soft tissues.
- The practitioner wants to avoid diffusion of excess cement in an extraction site, especially when there is a gap between the implant and the alveolus.
- The clinical situation makes removal of excess cement difficult (ie, for deeply subcrestal implants).
- The clinician anticipates substantial gingival recession to occur, compromising esthetics. A screw-retained provisional prosthesis avoids the placement of abutments with their metal-crown junction near the gingival sulcus.
- The clinician wants to be able to verify implant stability during the osseointegration period.

In all of the aforementioned cases, the screw-retained method is preferable for the provisional prosthesis. By the time the final prosthesis is placed, however, osseointegration will be completed and soft tissues will be healed. The risk of diffusion of excess cement will be greatly diminished, so that cement fixation, with its anticipated esthetic benefits, can be selected.

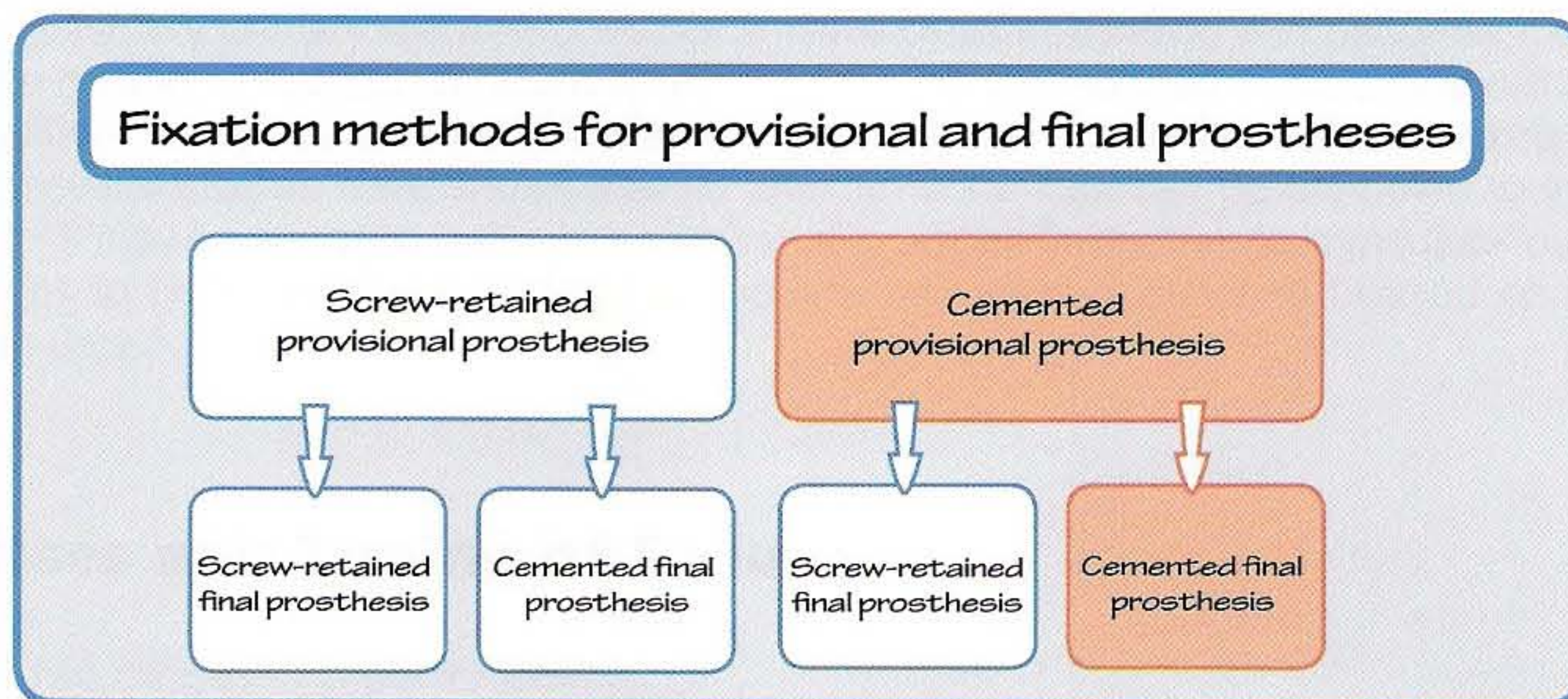


▲ **Fig 7-1d** Cemented provisional prosthesis and screw-retained final prosthesis.

Cemented provisional prosthesis and screw-retained final prosthesis

This combination (Fig 7-1d) is appropriate when:

- An esthetic failure in the edentulous maxilla requires management. A screw-retained final prosthesis allows the use of false gingiva made of acrylic resin or ceramic material.



▲ **Fig 7-1e** Cemented provisional and final prostheses.

Cemented provisional and final prostheses

This combination (Fig 7-1e) is appropriate when:

- Esthetic considerations are important for the provisional denture, because cementation allows better management of the emergence profile.

- The patient has a thin periodontal biotype. For these patients, final abutments are placed immediately to avoid disruption of the soft tissue attachment when the final prosthesis is prepared.
- The implant is angled too far buccally and requires correction. The screw access hole of a screw-retained prosthesis would be located on the buccal side of the crown and would be unesthetic.

In all of the aforementioned situations, cementation is the method of choice for retention of the provisional prosthesis. However, this mode of retention requires more chair time and attention, as the clinician must remove all excess cement. In such cases, the final prosthesis is cemented for the same reasons as the provisional prosthesis.

Chapter 8

FAILURE OF IMMEDIATELY LOADED IMPLANTS

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Adriana Agachi

Immediate-loading and delayed-loading protocols alike are predisposed to objective or subjective implant failures. An *objective failure* is when an immediately loaded implant, after having demonstrated satisfactory primary stability, does not achieve osseointegration and becomes mobile over the course of time. A *subjective failure* is when an immediately loaded implant fails esthetically. It is more difficult to decide whether the blame can be placed on the immediate-loading protocol, because several studies have shown that no specific bone loss can be attributed to immediate loading.¹⁻³ It may be possible that soft tissues react in a specific manner to immediate loading, but this remains to be established. So far, the opposite has been documented based on results of short-term data.⁴

▼ **Causes and Timing of Failure**

There are two causes of implant mobility:

1. Infection
2. Biomechanical problems

The less frequent of the two is infection, but when infection occurs it becomes quickly evident, usually within the first 3 to 4 weeks after immediate loading. It can be caused by:

- Infection of the bone during the surgery
- Infection of soft tissues that diffuses to the bone
- Residual postextraction infection of the alveolus
- Migration of excess cement to the bone

Implants fail more frequently because of mechanical loading; this type of mobility manifests later, between 4 and 12 weeks after loading. The causes are excessive mechanical stress exerted on the implants and deleterious micromovements at the bone-implant interface, in excess of its tolerance level. Tolerated micromovements vary from 30 μm for a machined surface⁵ to 100 μm for a roughened surface⁶; the tolerance increases to at least 250 μm when the surface is bioactive.⁷ These micromovements interfere with the osseointegration process that aims to establish secondary biologic stabilization. Furthermore, they cause resorption of the peri-implant bone, which had provided primary mechanical stability to the implant.

When the conditions of primary stability at the bone-implant interface are favorable, undifferentiated pluripotential mesenchymal cells arrive at the implant site and, following the osteoblastic differentiation pathway, differentiate into osteocytes. Osteoblasts lay down calcified tissue that participates in the biologic stability of the implant, and osseointegration is obtained.

When deleterious micromovements occur at the implant-bone interface, however, the mesenchymal cells arriving at the site are detoured from the osteoblastic differentiation pathway toward the fibroblastic pathway and, instead, become fibroblasts.⁷ The fibroblasts organize a fibrous encapsulation around the implant in which fibers are parallel to the implant axis.⁸ As this fibrous tissue becomes thicker, the implant becomes more mobile, leading to fibrointegration instead of osseointegration.

Mobile implants must be unloaded or removed as soon as possible, because implant mobility leads to horizontal resorption of the surrounding cortical bone. Failures of osseointegration are detected most frequently 4 to 12 weeks after loading. This is the time necessary for osteoclasts to resorb the original bone that participated in the purely mechanical primary stability.

Failure to osseointegrate can be attributed to:

- Insufficient primary stability associated with implant placement in bone of poor density
- Insufficient primary stability associated with implant placement in an extraction socket
- Inadequate splinting of implants supporting a complete or partial prosthesis
- The effect of constant peaks of stress on the implant because of imperfectly adjusted occlusion
- The effect of intermittent peaks of stress on the implant during mastication of certain foods

The presence of intermittent peaks of stress is enough to trigger bone resorption.⁹ However, when these stresses are eliminated in the first 3 or 4 weeks after immediate loading, it is still possible for the fibroblastic cellular differentiation pathway to revert to the original osteoblastic pathway.¹⁰⁻¹² Calcification can resume at the bone-implant interface, and osseointegration can still be obtained. After 4 to 6 weeks of mobility at the bone-implant interface, the progression toward fibrous encapsulation is more difficult to stop.¹²

▼ Clinical Signs of Osseointegration Failure

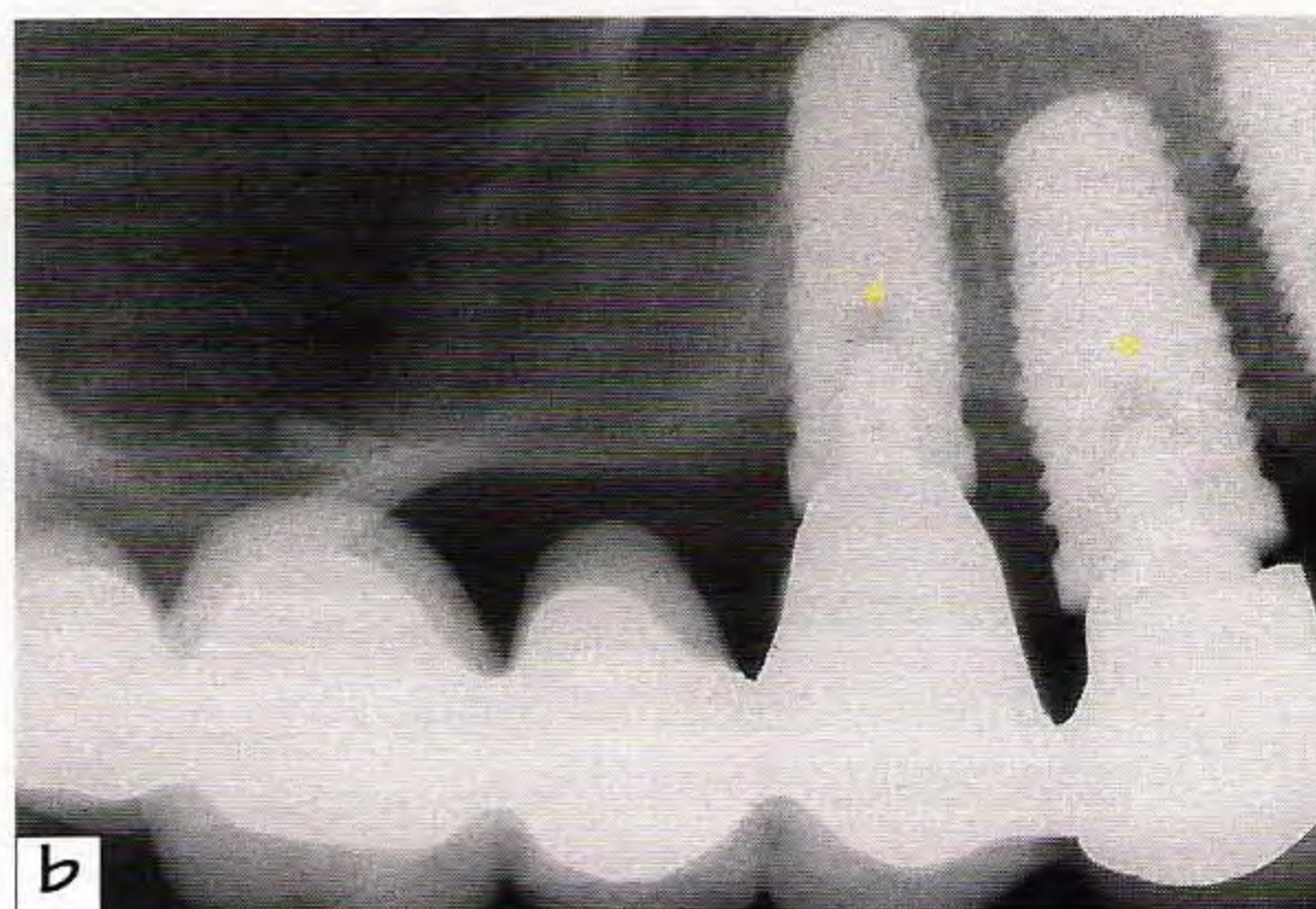
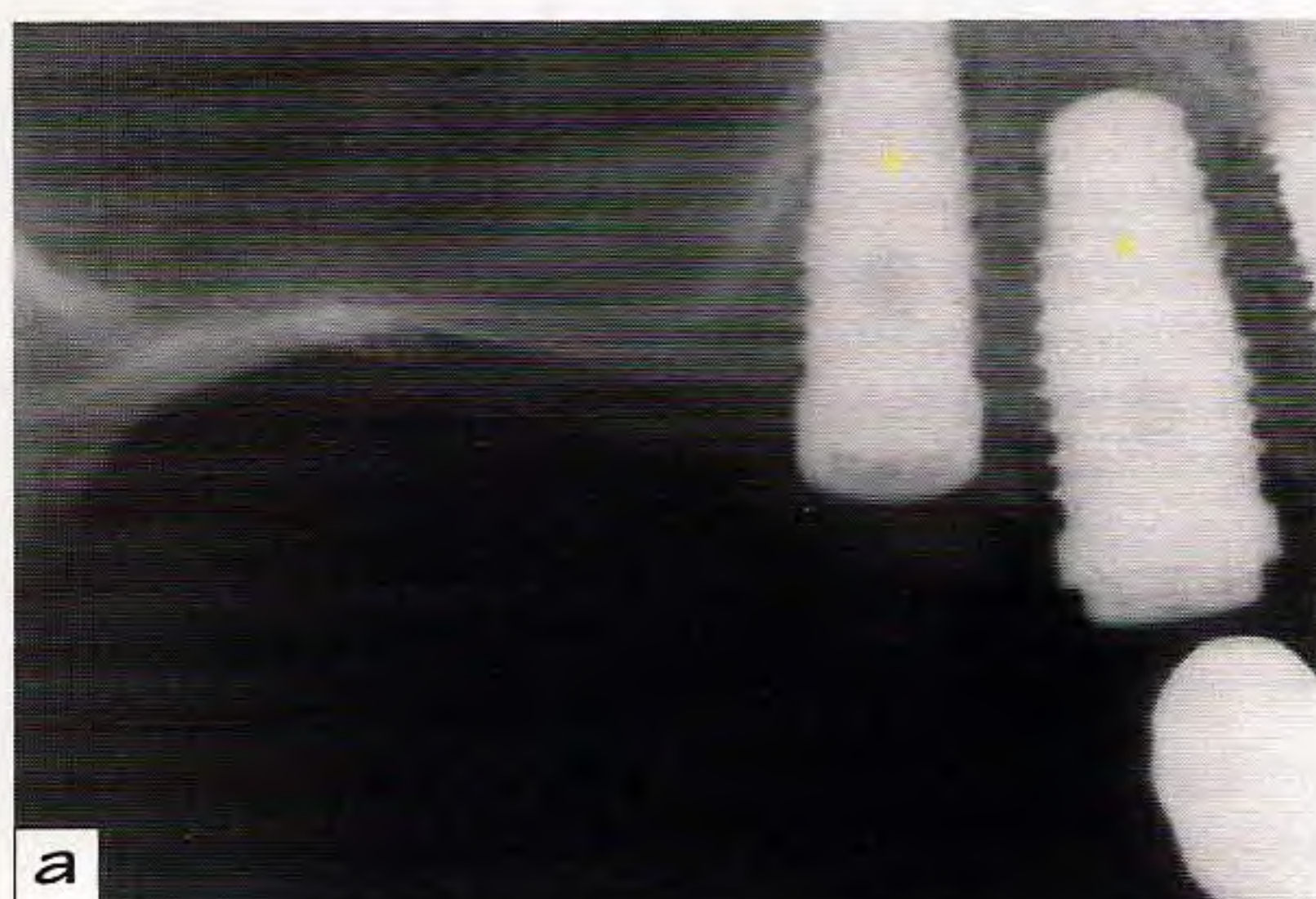
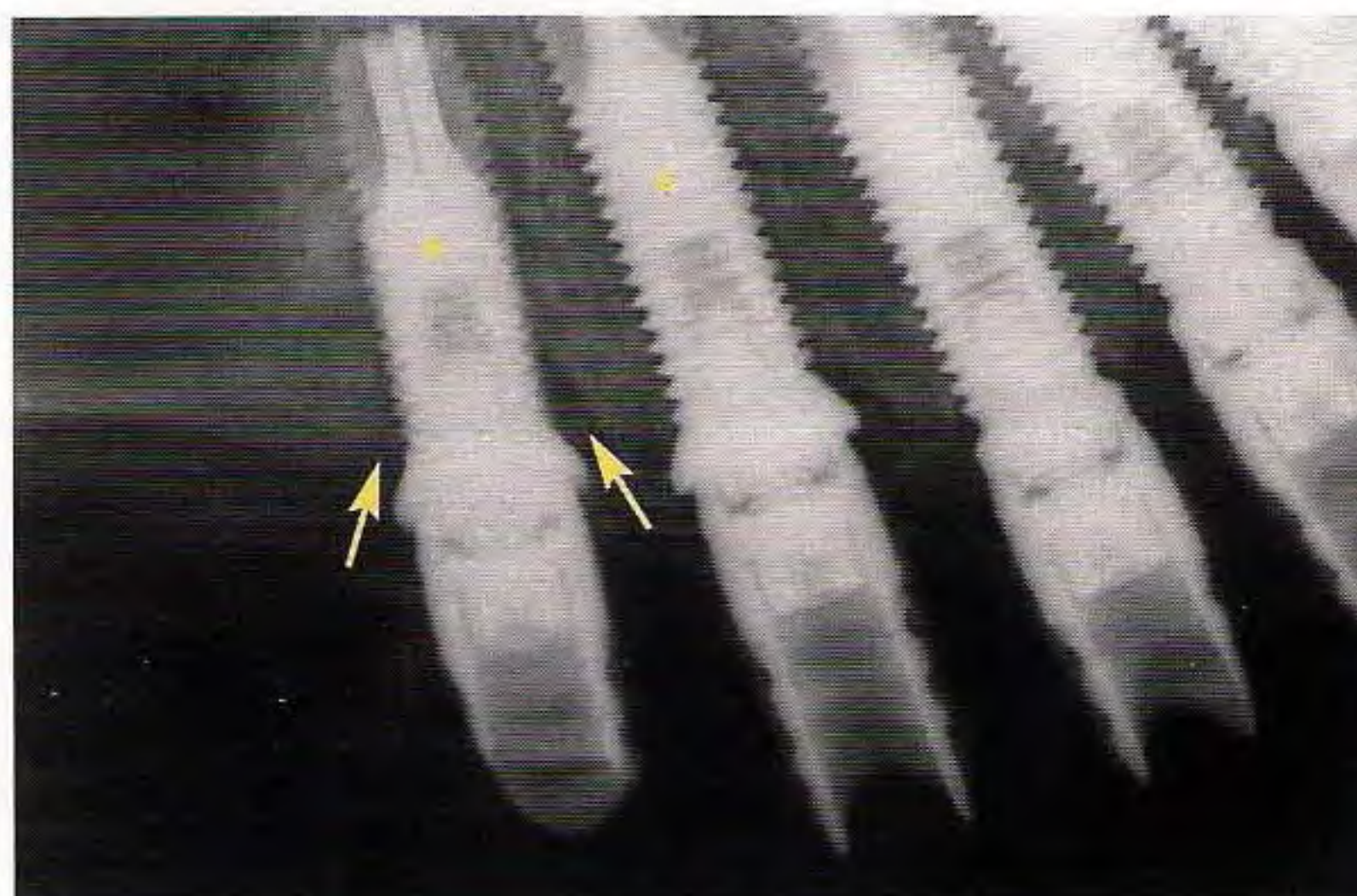
The clinical signs of osseointegration failure are:

- Clinical mobility
- Sensitivity during mastication
- Sensitivity to percussion
- Possibly, the presence of inflammation

When implant mobility is suspected or the patient complains of symptoms, a periapical radiograph should provide useful information. The presence of peri-implant radiolucency indicates that osseointegration has failed. However, clinical signs of mobility can exist even in the absence of this radiographic finding. A V-shaped area of resorption located at the bone crest around the implant reflects a bone response to biomechanical overloading (Fig 8-1).

The radiograph in Fig 8-1 shows two implants that became mobile 3 months after placement. The failure followed fracture of the maxillary complete denture in the canine region. A more or less continuous peri-implant radiolucency is visible around the implant in the position of the right canine.

► **Fig 8-1** Radiograph of mobile implants. Implants in the sites of the maxillary right first premolar and canine (*left*) became mobile after fracture of the prosthesis they were supporting. The implant in the site of the first premolar shows signs of a V-shaped osseous defect (*arrows*), indicating that the bone has been overloaded.



▲ **Fig 8-2** Replacement of mobile implants with larger-diameter implants. (a) Replacement of the mobile, standard 3.75-mm-diameter implants shown in Fig 8-1, with two conical implants of 4.00 mm (*left*) and 5.00 mm (*right*) in diameter. The new implants were allowed a submerged healing. The prosthesis was shortened to exclude the new implants and continued to function as a provisional restoration. (b) Incorporation of the newly placed implants in the final prosthesis.

This radiographic feature is not visible around the most distal implant; however, V-shaped bone resorption at the bone crest, indicating overloading of bone, is clearly noticeable.

▼ Management of Failed Implants

Late failures

When an implant is clearly mobile, it should be removed. The failed implant can be replaced with an implant of larger diameter (Fig 8-2) and, wherever possible, greater length. After removal of the failed implant, the socket should be carefully enucleated and then enlarged with the bur corresponding to the size of the larger implant.¹³ The larger implant should be able to achieve satisfactory primary stability. If the insertion torque of the newly placed implant is greater than 40 Ncm, the implant can be immediately loaded so it can help support the prosthesis.

If the primary stability is less than 35 Ncm, the implant is allowed a submerged healing period. Thus, implant treatment is not interrupted,¹³ although the accelerated treatment course may be abandoned. The newly placed implant will help to support the final prosthesis after the recommended time for traditional osseointegration has transpired.¹³

Failure within the first 6 weeks of loading

When implant mobility has been identified with certainty, it is sometimes possible to restore its clinical stability, but only when the mobility has been discovered during the first 6 weeks after immediate loading.

If the implant cannot be replaced with an implant of larger diameter or if the mobile implant is not indispensable to the function of the prosthesis, eg, the last implant supporting a maxillary complete denture, it can be removed from function and further protected from loading stress.

The unloaded implant should be followed for a 3-month period, during which time its mobility and related symptoms are evaluated every 4 weeks. At the time of the first month's examination, the clinical signs of mobility and the related symptoms should have abated. Objective assessors of mobility, such as Periotest (Medizintechnik Gulden) or Osstell (Osstell), are very useful.

If implant mobility has not decreased by the second month's assessment, the clinician should radiograph the implant and then remove it. However, if the Periotest or Osstell suggests that mobility is decreasing, the clinician should wait until the end of the third month. At that time, a finding of progressively improving stability will give assurance that the implant can be restored to function.

Clinicians who do not have access to objective evaluation devices can measure implant stability manually and make a clinical judgment about the extent to which clinical stability has improved while the implant has been out of function. Before attaching the implant to the final prosthesis, however, the clinician should test the level of osseointegration by applying a counter torque of 20 Ncm or by observing how the implant withstands occlusal stress for 3 months in support of a provisional prosthesis.

In a clinical trial in which 11 implants were identified as mobile, 7 mobile implants (63%) were able to recover clinical stability after they were left to heal unloaded for several months (unpublished data, 2007). These implants were successfully returned to function.

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Chapter 9

KEY CONCEPTS OF TREATMENT PLANNING

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Part 1 of the book provides the basic and theoretic information specific to immediate-loading protocols. Part 2 explains and illustrates the practical application of these protocols. For each group of indications, the strategies and the appropriate treatment options are discussed. The different phases—preoperative, surgical, and prosthetic—are presented in detail, as are the sequence of procedures.

▼ **Key Information for Each Treatment Option at a Glance**

In the subsequent chapters, the most important practical issues of each treatment option are listed in a format that can be grasped at a glance. The aim is to help the reader to rapidly discern the best solution to any clinical situation and its related practical aspects.

The key points are arranged in two groups:

1. A panel of eight pictograms with information covering the most important aspects of the treatment options:
 - Technical difficulty of preparing the provisional prosthesis
 - Degree of coordination among of the members of the treatment team
 - Amount of time required for treatment
 - Number of implants needed
 - Importance of esthetic considerations
 - Extra costs specific to the immediate-loading protocol compared with the conventional treatment
 - Degree of risk involved in the immediate-loading treatment
 - Amount of documentation in the literature

2. A chart depicting the sequence and timing of the steps in each treatment option, so that all members of the treatment team can identify the phases in which they participate in treatment and their roles. The sequence of the phases is divided into the following segments:

- Preoperative phase
- Surgical phase
- Provisional prosthetic phase
- Final prosthetic phase

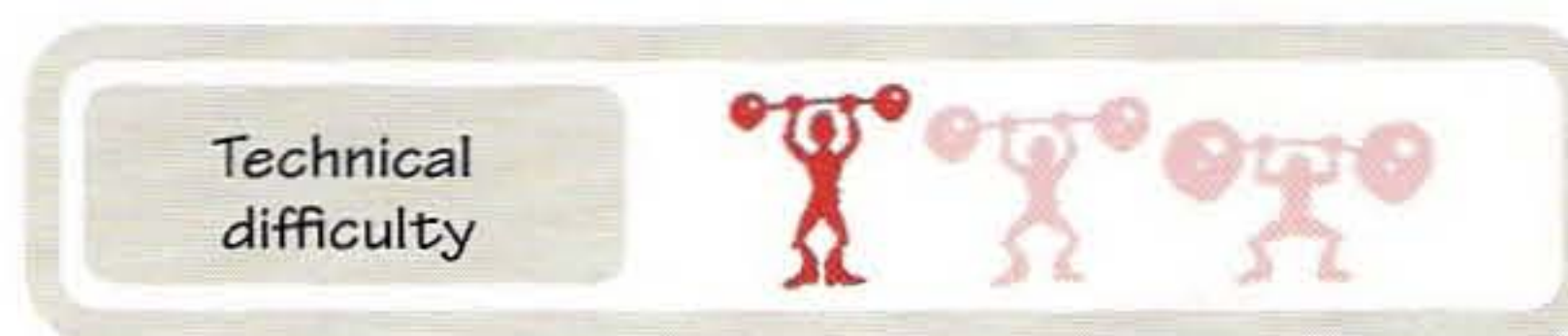
By keeping this sequence of events in mind, clinicians can determine the best way to harmoniously incorporate the special tasks required for each phase into the overall plan.

Content of the pictogram panel

Each key point is classified into three levels.

Technical difficulty

This category deals primarily with the prosthetic phase. The level of difficulty depends on whether the prosthesis is prepared at chairside or in the laboratory and whether or not precise occlusal adjustments are needed. The procedure is most difficult when the prosthesis must be prepared at chairside and requires occlusal adjustment or when a final prosthesis made in the laboratory needs fine occlusal adjustments after placement.



Technical difficulty is low

The prosthesis is made in the laboratory and is designed to be kept out of occlusion. The prosthetic phase presents no particular technical challenge.



Technical difficulty is average

The prosthetic phase presents the prosthodontist with some technical problems and requires close attention. The clinician prepares the prosthesis at chairside or executes precise occlusal adjustments on a laboratory-made prosthesis.



Technical difficulty is high

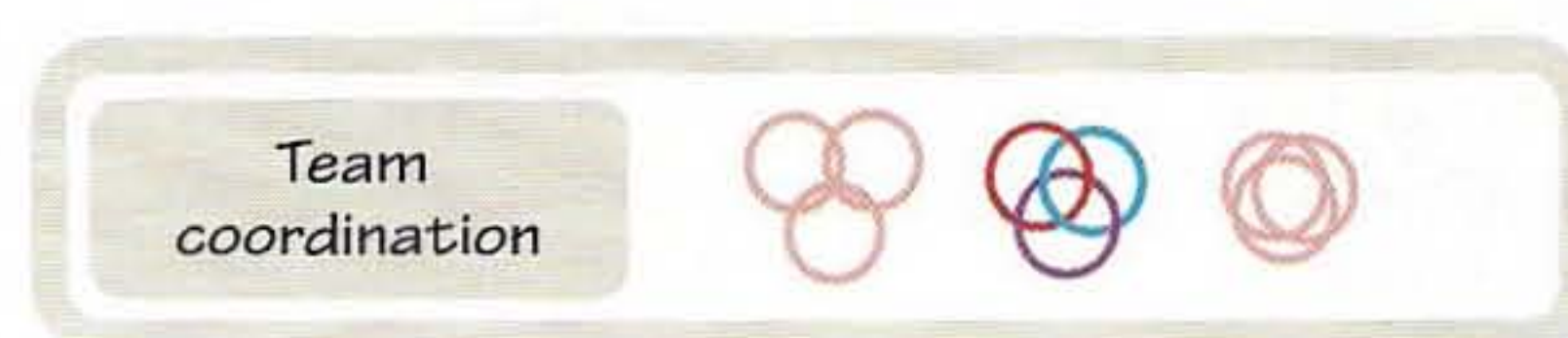
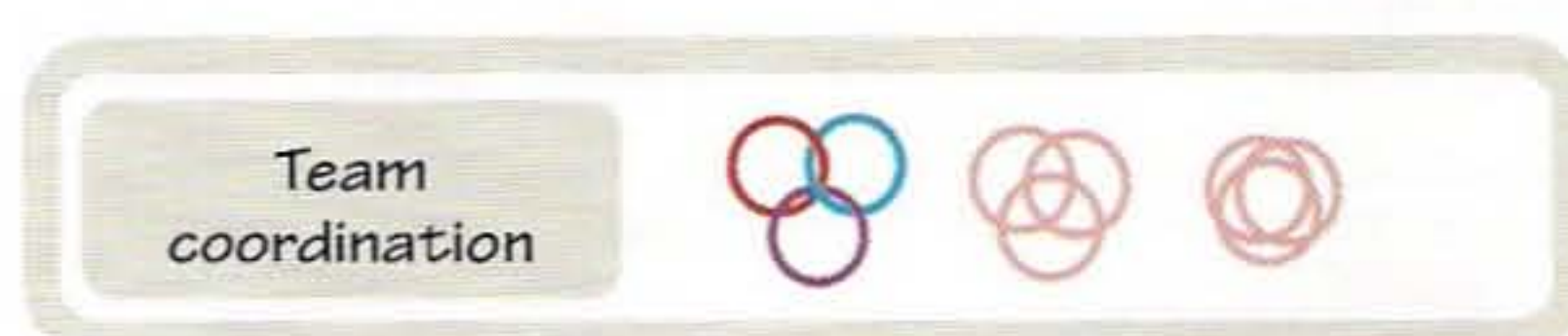
The prosthetic phase takes place exclusively at chairside, and presents difficulties in preparation of the provisional prosthesis and adjustment of the occlusion, or involves fine occlusal adjustment of a final prosthesis made in the laboratory.

Team coordination

To carry out an immediate-loading procedure as effectively and as expeditiously as possible, all members of the treating team must know precisely when they will be called on to participate in the enterprise. The patient should be aware that short and precisely delimited schedules will have to be respected. The prosthodontist will have to work after the surgeon at the same appointment or on a strict schedule after completion of the surgical procedure. Coordination between these practitioners does not constitute a major difficulty; if the laboratory is not involved in preparing the provisional prosthesis, the need for coordination can be considered limited.

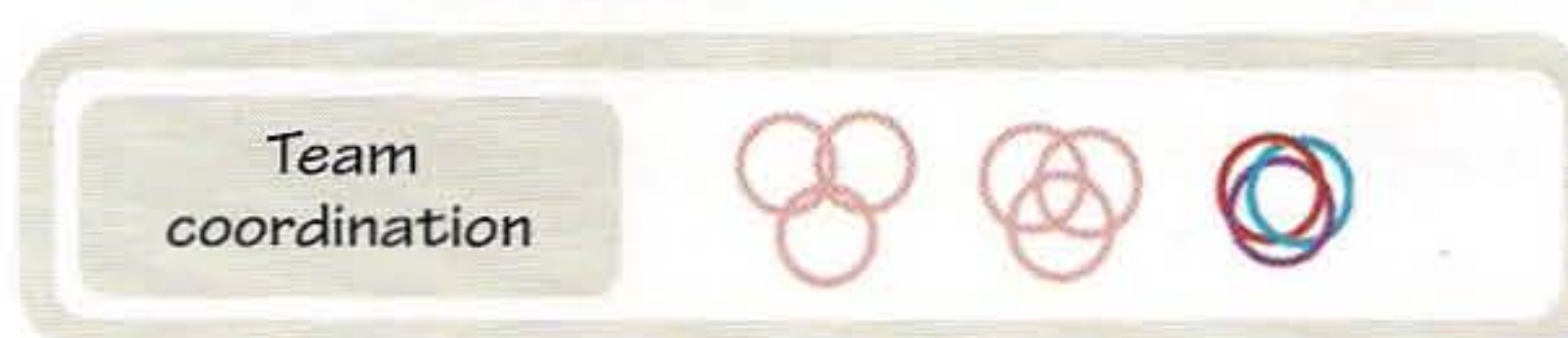
When the laboratory is involved, the availability of the laboratory is the principal concern, because its participation is the key element in the precise unfolding of the treatment within the preconceived time frame. The practitioners should be certain that they have chosen a laboratory technician who is experienced in this treatment modality, because reliability and adherence to a well-defined schedule are critical.

The level of team coordination will vary according to the extent and the difficulty of the restoration to be prepared in the laboratory.



Team coordination is limited

A relatively relaxed level of coordination between team members suffices because time constraints are weak. The laboratory is not included in the schedule because the prosthesis is made at chairside.



Team coordination is moderate

Although a certain amount of coordination with the laboratory is needed, the team does not have to conform to demanding, tight time constraints. The laboratory is involved immediately after implant placement but the prosthetic work is relatively simple to perform. In addition, in the absence of any critical esthetic considerations, the provisional prosthesis can be completed within 72 hours rather than a more hectic 24-hour period.

Team coordination is tight

Strict coordination is indispensable because time constraints are critical. The laboratory is involved immediately after implant placement in a complex prosthetic design that requires considerable time to be completed, or the prosthetic work must be urgently prepared in the laboratory without delay because of the patient's psychologic requirements. In the latter case, the prosthesis must be, at best, completed on the day of implant placement or, at least, delayed no more than 24 or 48 hours, not 72 hours.

Treatment time



Treatment time

This information is important for planning the prosthetic phase and for estimation of the treatment costs. In addition, an understanding of time requirements eases office time management. These guidelines estimate the average time it would take a practitioner with average experience to complete a given task.

Treatment time



Treatment time



Treatment time is limited

The prosthesis is made in the laboratory and is to be kept out of occlusion. The provisional prosthetic phase requires a relatively small time commitment from the prosthodontist, especially because fine occlusion adjustment is not required.

Treatment time is average

The provisional prosthesis requires more of the practitioner's time. It is fabricated at chairside and placed out of occlusion or fabricated in the laboratory but requires occlusal adjustment.

Treatment time is extended

The provisional prosthetic phase requires a considerable amount of the practitioner's time. It must be highlighted in the schedule as requiring a long and tiring appointment. Either the provisional prosthesis is prepared at chairside and the prosthodontist has to adjust the occlusion carefully, or the prosthesis is fabricated in the laboratory but much time must be spent carefully adjusting the occlusion (eg, for an immediately delivered final prosthesis in the edentulous mandible).

Number of
implants



Number of implants

The number of implants required to provide a satisfactory support varies from case to case. There is no question for replacement of a single crown, but the number of implants necessary can widely vary when an edentulous mandible or maxilla is rehabilitated. The number of implants depends on the risk involved in the treatment. Sometimes, to minimize the risk of failure, the authors will recommend including more implants in the treatment plan than is normally recommended in the literature. Therefore, the num-

Esthetic
requirements



ber of implants required for treatment may vary from 1 to 10. One implant will suffice for an anterior crown but a maxillary complete denture may require 10.

Esthetic
requirements



Esthetic requirements

Where esthetics prevail, the surgeon must have specific knowledge about how to place implants in these sites. Implant treatment in these sites requires careful preparation and meticulous execution of

Esthetic
requirements



implant placement. These sites also require the prosthodontist to be experienced in development of the best emergence profile and management of soft tissues.

Esthetic requirements are low or nonexistent

The treatment does not require any specific attention to esthetics. The criteria for implant positioning are flexible. There is no need for the prosthodontist to manage the soft tissues in a specific way.

Esthetic requirements are moderate

Esthetic requirements are modest, and the surgeon and prosthodontist need pay no extraordinary attention to soft tissue management. It is nevertheless advisable to adhere to three-dimensional placement criteria as faithfully as possible.

Extra costs



Esthetic requirements are high

Esthetic considerations prevail and are critical. The surgeon and the prosthodontist should have knowledge and experience of soft tissue management. The surgeon must adhere to scrupulous implant pla-

Extra costs



cement criteria, and the prosthodontist must be experienced in prosthetic means of soft tissue management.



Extra costs



Extra costs specific to the immediate-loading protocol

Immediate loading may incur extra costs for patients compared with fees for traditional provisionalization, because immediate loading may necessitate the use of specific, expensive materials. In some cases, material costs are similar. The initial demands on the practitioner's time are greater with immediate loading, but they diminish considerably during the course of treatment.

Extra costs are low

Only a modest increase in fee, if any, is required. Additional prosthetic materials are not required, the laboratory makes the prosthesis, and the clinician's chair time is not extended. Reuse of materials from the provisional prosthesis for the final prosthesis can also help to reduce costs.

Risk
assessment



Extra costs are moderate

A moderate increase in fee is required because some specific additional prosthetic materials are required or the prosthodontist must spend additional time at chairside.

Risk
assessment



Risk
assessment



Extra costs are substantial

Considerable amounts of supplementary prosthetic materials are required, and the prosthodontist has to spend much more time at chairside. This forces a major increase in the total fee.

Risk assessment

Before treatment, the clinician has to outline for the patient the potential risks of the immediate-loading procedure. The clinician and patient must analyze the risk-benefit ratio and discuss alternative measures that can be taken should the immediate-loading protocol fail. The risk analysis should be based not only on applicable success rates published in the literature but also on the parameters of the individual case and the practitioner's own experience in the field.

Documentation



Documentation



Documentation



Additional risk is low

The risk specific to immediate loading is minimal and the risk factors are readily under control. Success rates published in the literature for the treated indication are high and are comparable with those for traditional-loading protocols.

Additional risk is moderate

The risks associated with immediate loading are not negligible, but the clinician should be able to manage them without undue difficulty.

Additional risk is high

Risk factors specific to immediate loading do exist. The clinician should scrupulously adhere to all the principles of immediate loading and make certain that all the conditions required for a successful outcome are in place.

Documentation in the literature

Not all indications for immediate loading are equally well documented in the literature. However, neither extensive nor scarce documentation gives assurance of the reliability or the risk of the procedure.

Documentation in the literature is scarce

Few studies on this indication have been published.

Documentation in the literature is moderate

A reasonable number of studies on this indication have been published.

Documentation in the literature is extensive

This indication for immediate loading has been abundantly documented in the literature.

▼ Principal Determinants of Treatment

Depending on the type of rehabilitation involved, patients, with the guidance of their clinician, are motivated to seek immediate-loading treatment for a variety of reasons, including:

- *Psychologic need.* The patient's emotional distress at an unsightly appearance drives him or her to seek restoration of the missing teeth as rapidly as possible.

- *Uneasiness in the dental chair.* The patient wants rapid restoration of the missing teeth, but has difficulty in submitting to a drawn-out dental procedure.
- *Difficulty in keeping appointments.* Because of busy schedules or other reasons, the patient is unavailable for multiple appointments and therefore prefers rapid treatment.
- *Financial incentive.* A final prosthesis is immediately delivered, so the patient will not have to pay for a provisional denture.

As discussed in chapter 3, any one of these requirements may be the principal determinant of treatment that persuades the clinicians and the patient, working together, to select a given immediate-loading protocol and treatment time frame.

Chapter 10

TREATMENT OF THE EDENTULOUS MANDIBLE

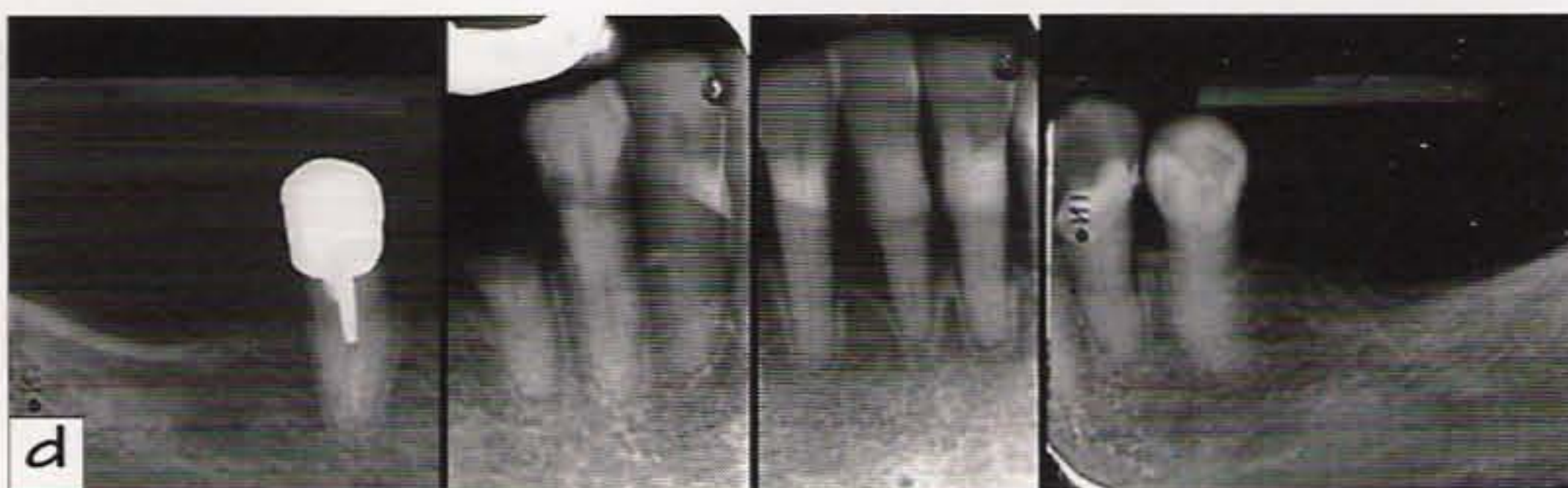
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Rehabilitation of the edentulous mandible is particularly well adapted to immediate loading. Historically, immediate loading was first employed for treatment of this type of edentulism. This indication remains the best documented immediate-loading procedure,¹⁻⁵¹ with a total of 593 patients and 2,693 implants being cited in the literature.⁵² The reported average success rate is 97.3%, which is equivalent to that of the standard technique. Furthermore, numerous studies have reported 100% success rates for complete mandibular prostheses supported, in most cases, by 5 or 6 implants placed between the mental foramina.

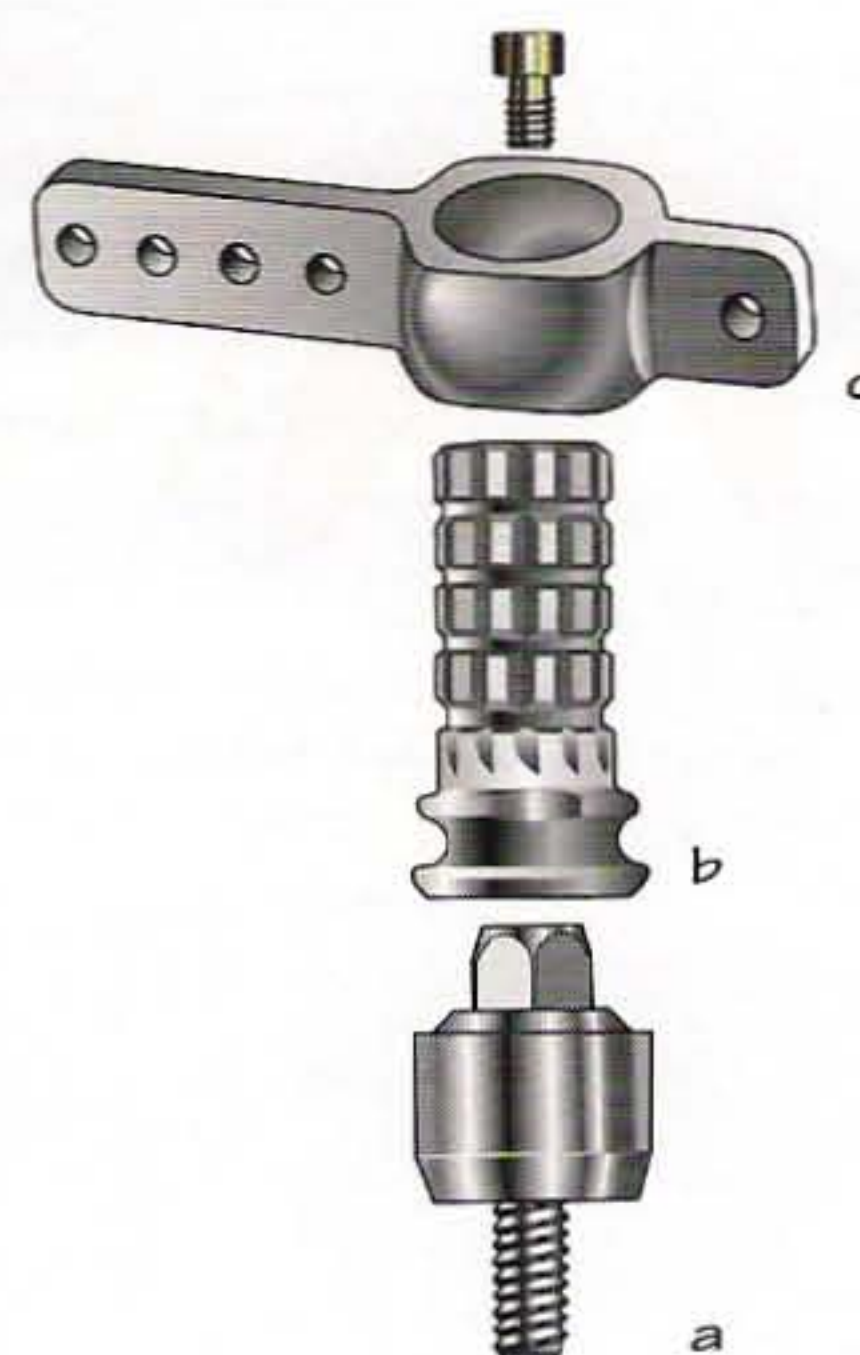
Treatment of the edentulous mandible includes:

- Rehabilitation of the mandible that has been edentulous for some time; all implants will be placed in healed sites (Figs 10-1a and 10-1b).
- Rehabilitation of the mandible that is "becoming edentulous" after the extraction of all remaining hopeless teeth; all implants will be placed in extraction sites (Figs 10-1c to 10-1e) or in a combination of healed and extraction sites (Figs 10-1f to 10-1h).

The overall approaches the clinician should adopt for clinical management of these two situations are quite similar, which is why both protocols are presented in one chapter. However, their differences and their individual characteristics will be emphasized as well as the difficulties that may be encountered with each.



▲ **Fig 10-1** Clinical conditions included in the term *edentulous mandible*. (a and b) Edentulous mandibles that present only healed sites for implant placement. (a) Clinical appearance of the edentulous mandible. (b) Panoramic radiograph confirming the total absence of teeth. (c to e) Mandibles that are about to become edentulous and will present only extraction sites for implant placement. (c) Clinical situation prior to extraction. Note the advanced bone loss. (d) Periapical radiographs prior to extraction, confirming the need for extraction of all remaining teeth. (e) Appearance of the mandible after extraction of all remaining teeth. (f to h) Edentulous mandibles that present both healed and extraction sites for implant placement. (f) Clinical appearance prior to extraction. Note the fixed partial denture extending from the right canine to the left lateral incisor and the presence of tartar. (g) Periapical radiographs prior to extraction, confirming the need for extraction of all remaining teeth because of severe bone loss. (h) Clinical view after extraction.



► **Fig 10-2** Specific prosthetic components developed for the conversion prosthesis technique. (a) Transgingival immediate occlusal loading abutment. (b) Provisional cylinder and its screw. (c) Distal extension.

▼ Conversion Prosthesis Technique

To facilitate immediate loading in the edentulous mandible, a special protocol has been developed; the *conversion prosthesis technique* incorporates prosthetic components specifically devised for immediate loading.^{32,36} Before the different treatment options can be considered, the principles of this protocol must be understood.

This procedure is used to convert a removable denture, whether or not it is still in use, to a screw-retained fixed prosthesis. The underlying principle of this protocol is simple; it requires only a few specific prosthetic components for implementation (Fig 10-2). The process involves seven major steps (Fig 10-3):

1. Fabrication of a removable denture, if patient does not already have one, or examination of the current denture for suitability
2. Placement of implants and abutments, usually in the anterior region, and, in some cases, in posterior sites as well
3. Creation of slots in the prosthesis at the place it will fit over the implants and creation of space for the extensions
4. Placement of provisional cylinders and extensions over the implants
5. Try-in of the prosthesis on the cylinders and extensions
6. Attachment of the prosthesis to the provisional cylinders that are serving as abutments
7. Finishing and polishing of the inner and outer surfaces of the prosthesis

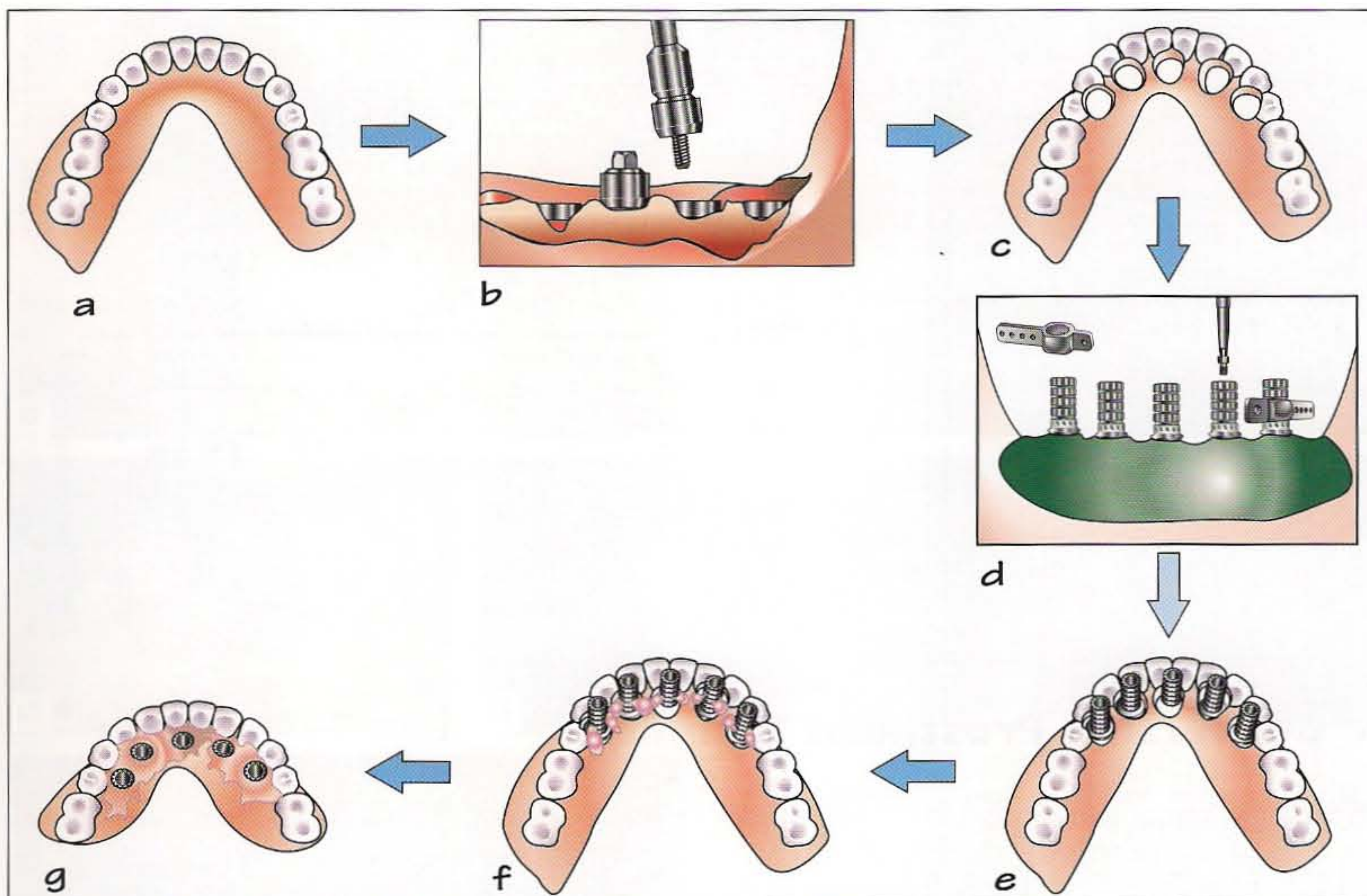
▼ Treatment Options

The immediate-loading protocol chosen for rehabilitation of a mandible that is or is becoming edentulous should be the option that is defined by the principal determinant of treatment for that case. The scope of these treatment options is illustrated in Fig 10-4a in the form of a decision tree with successive decision nodes.

Decision nodes

First decision node

In both treatment situations, rehabilitation of an edentulous mandible and rehabilitation of a mandible that is becoming edentulous, clinicians have to choose between the following two options: (1)



▲ **Fig 10-3** Steps in the conversion prosthesis technique. (a) Fabrication of a removable denture if the patient does not already have one. (b) Placement of the implants and their abutments. (c) Creation of slots in the prosthesis through which the cylinders can pass and provide space for the extension. (d) Placement of provisional cylinders on the implants and the extensions if required. (e) Placement of the prosthesis on the cylinders and their extensions. (f) Attachment of the prosthesis to the provisional cylinders. (g) Finishing of the exterior surface and interior surface of the conversion prosthesis.

construction of a provisional prosthesis that the patient will wear for 3 to 6 months before receiving a final prosthesis or (2) immediate construction of a final prosthesis with a metal frame.

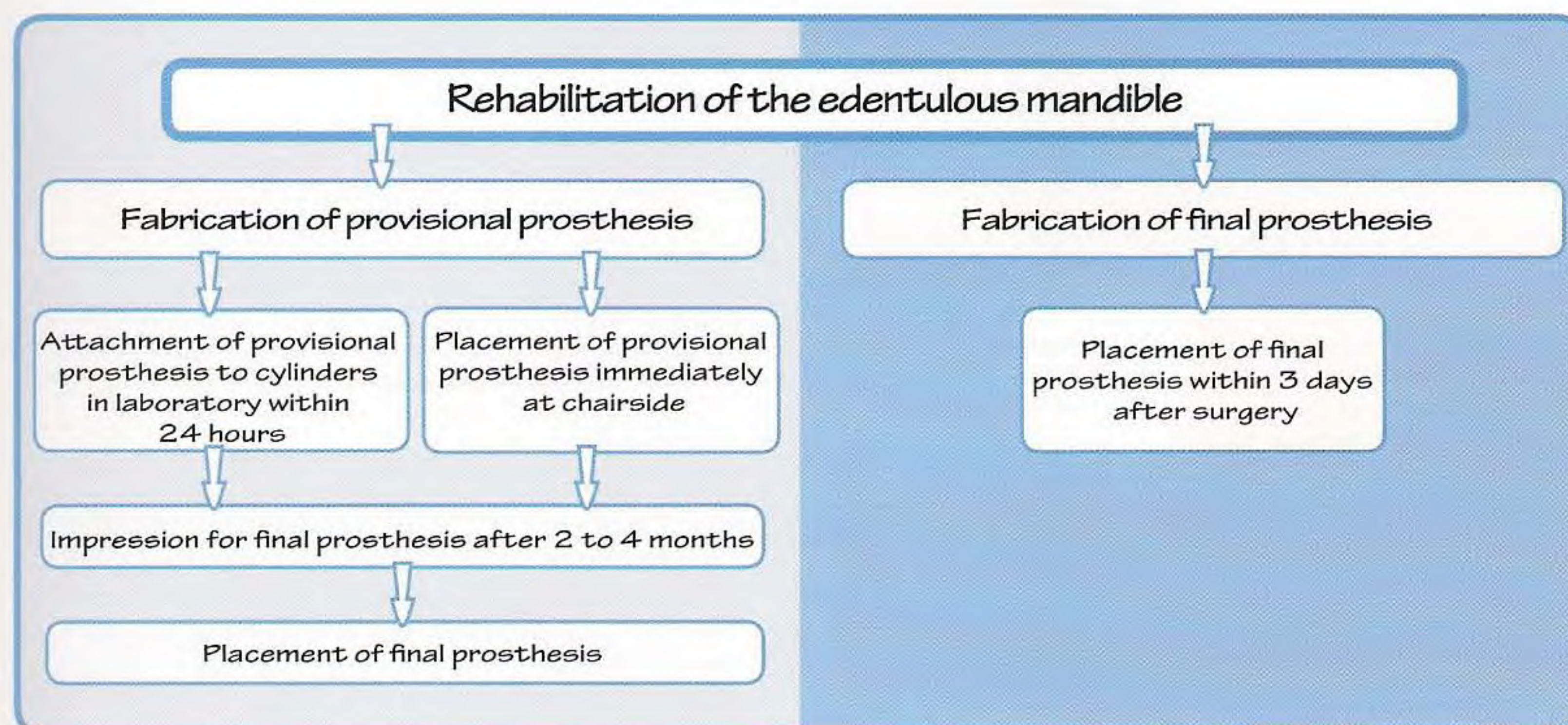
The immediate construction of a final prosthesis might appear a surprising option, because simple prudence and good clinical practice would seem to require that clinicians verify the success of osseointegration before taking this definitive step. However, this alternative has a legitimate place in dental treatment, given its high rate of documented success. Hence, if the principal determinant of treatment strongly favors this approach, it is appropriate for clinicians to select it, in accordance with the conditions outlined in the forthcoming discussion of option 3, with full confidence that this option is as dependable as any other.^{18,23,35}

For this procedure, the laboratory constructs the final prosthesis with a metal frame from an impression the prosthodontist has taken. The clinician delivers the prosthesis to the patient sometime in the first 3 days following surgery.

If the clinician chooses "construction of a provisional prosthesis" on the decision tree, a second decision is required.

Second decision node

The clinician will have to decide whether the provisional conversion prosthesis should be (1) attached to the implants in the laboratory and placed in the mouth during a second visit or (2) attached to the implants at chairside and placed in the mouth immediately after surgery, during the same appointment. In addition, for patients who already have a removable prosthesis, clinicians will



▲ **Fig 10-4a** Decision tree showing all treatment options available to rehabilitate the edentulous mandible. These options are common to healed and extraction sites.

have to decide if the existing denture can serve satisfactorily as a basis for the conversion prosthesis technique.

After the osseointegration of the implants has been verified, the preparation of the final prosthesis can proceed.

Treatment options for rehabilitation of an edentulous mandible

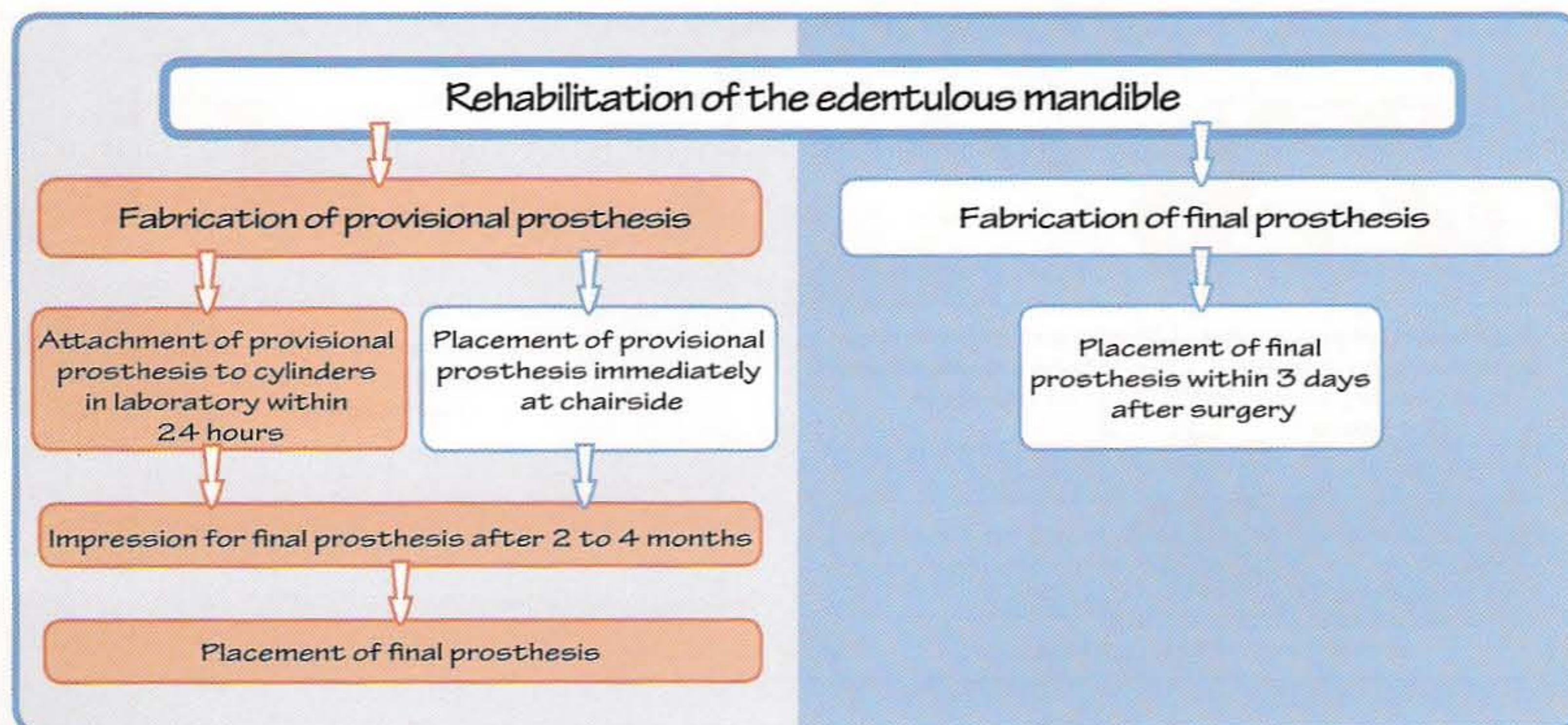
- Option 1:** A screw-retained provisional prosthesis is placed within 24 hours after surgery; the prosthesis is attached to the provisional cylinders in the laboratory.
- Option 2:** A screw-retained provisional prosthesis is placed immediately after surgery; the prosthesis is attached to the provisional cylinders at chairside.
- Option 3:** A screw-retained final prosthesis is made in the laboratory and placed within 72 hours.

Treatment option 1

Fixed screw-retained provisional prosthesis placed within 24 hours after surgery; the prosthesis is attached to the provisional cylinders in the laboratory (conversion of a removable denture to a fixed prosthesis).

This option (Fig 10-4b) is chosen when:

- The principal determinant of treatment is the comfort of the patient. The patient is reluctant to sit through a protracted combined surgical and prosthetic appointment that could last 3 to 5 hours. The treatment can be divided into two separate appointments of a more suitable length, on the same day or on 2 consecutive days.
- The implants' axes permit the screw access path to emerge on the lingual surface in the anterior segment and on the occlusal surface in the posterior quadrants, or even more lingually, at a distance from the teeth.



▲ **Fig 10-4b** Treatment option to rehabilitate a mandible that is edentulous or becoming edentulous when the principal determinant of treatment is the comfort of the patient. The treatment sequence is in red.

The conversion prosthesis procedure requires:

- A removable denture that is ready for conversion before implant placement.
- Specific prosthetic components developed for the conversion procedure (see Fig 10-2).

The prosthesis is affixed to the cylinders in the laboratory. The clinician takes an impression of the transgingival abutments in the mouth as well as a wax bite registration of the interocclusal relationship. The laboratory makes the appropriate openings in the removable denture, attaches it to the provisional cylinders, and finishes and polishes the converted prosthesis.

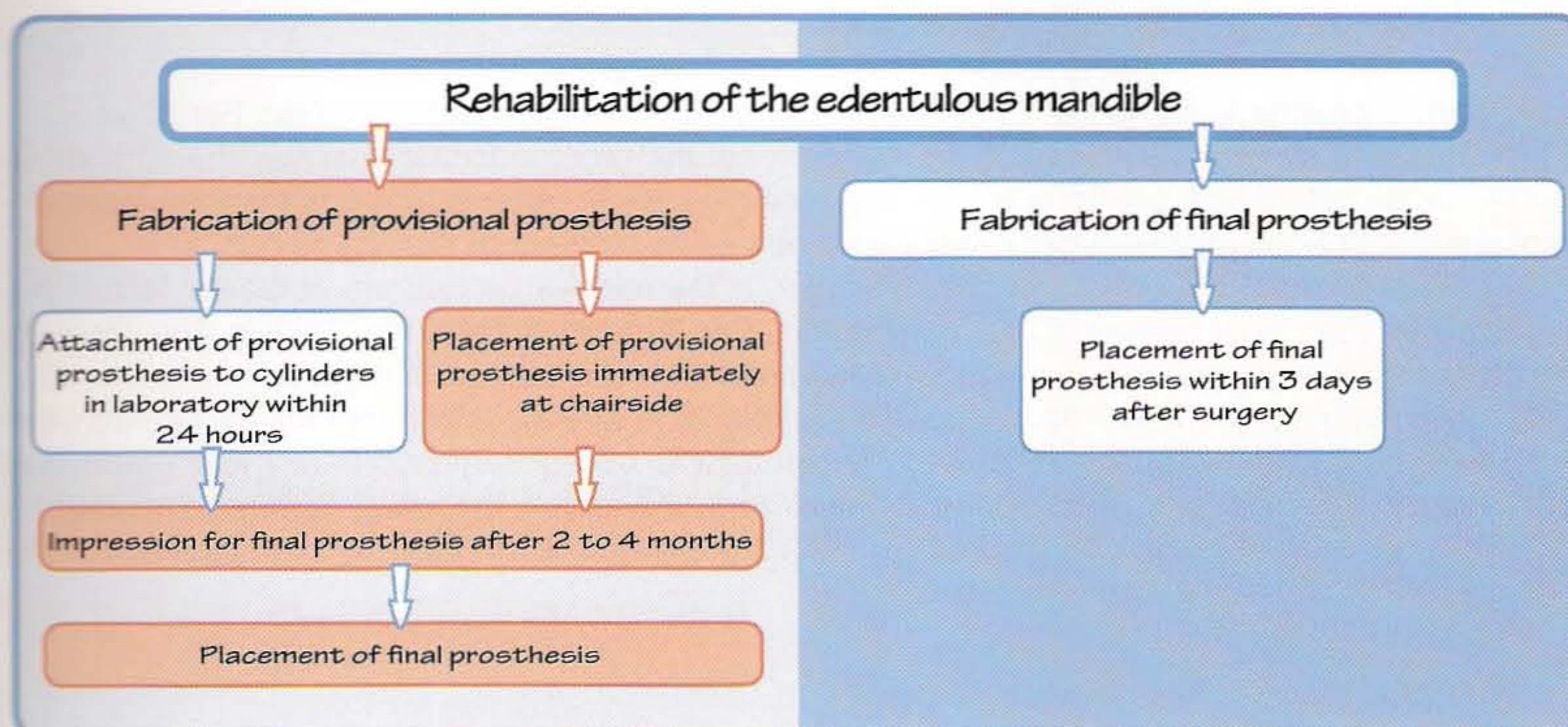
The clinician can deliver the fixed provisional prosthesis to the patient as soon as 3 hours and no more than 24 hours after surgery. The procedure can unfold in 1 of 2 ways:

1. The laboratory is located in the dental office or nearby. The patient can rest comfortably in the waiting room of the office while waiting for the laboratory to complete the splinting and finishing of the converted prosthesis. In this way, treatment can be completed in a single day during two sessions that are not uncomfortably protracted. In the first session, 2 or 3 hours long, the surgeon places the implants and the prosthodontist takes the impression. In the second, about 1 hour long, the prosthodontist places the prosthesis and adjusts its occlusion.
2. The laboratory is located at some distance from the dental office. The clinician will have to postpone placement of the converted prosthesis until the next day. This has the advantage of allowing time for the patient to recover after a long surgical session.

The time required for osseointegration of implants is at least 2 to 3 months for healed sites and 3 to 4 months for extraction sites.

Advantages

- The comfort of the patient is respected, because only the surgical phase is endured; the 1- to 3-hour prosthetic phase in the chair is avoided.
- The treatment is easier for the prosthodontist because the laboratory assumes the demanding and delicate task of attaching the removable denture to the implants and spares the restorative dentist from having to attach it painstakingly at chairside.
- For the prosthodontist, chair time is freed for treatment of other patients.
- Because chair time is reduced, the cost to the patient can also be lowered.



▲ **Fig 10-4c** Treatment option to rehabilitate a mandible that is edentulous or becoming edentulous when the principal determinant of treatment is the patient's psychologic need. The treatment sequence is in red.

- Unlike the option that provides an immediate final prosthesis, this option allows the clinician to manage implant failure with relative ease.

Disadvantages

- The patient is deprived of the fixed prosthesis for several hours or for an entire day after surgery.
- There is always the possibility that the bite registration is flawed and the prosthetic phase will have to be repeated.

Treatment tip:

It is advisable to perform the conversion prosthesis stage in the laboratory instead of chairside. This option spares the patient a stressful 3- to 5-hour session in the dental chair. The prosthodontist is spared a painstaking task that is best accomplished in the laboratory. The prosthodontist must be sure to take a good impression for the laboratory to use. This option does require faultless coordination between the prosthodontist and the laboratory.

Treatment option 2

Fixed screw-retained provisional prosthesis placed immediately after surgery; the prosthesis is attached to the provisional cylinders at chairside (conversion of a removable denture to a fixed prosthesis).

This option (Fig 10-4c) is chosen when:

- The principal determinant of treatment is the psychologic needs of the patient. The patient does not want to be left edentulous after surgery.
- The implant axes permit the screw access path to emerge on the lingual surface in the anterior segment and on the occlusal surface in the posterior quadrants, or even more lingually, at a distance from the teeth.

This conversion prosthesis procedure requires:

- A removable denture that is ready for conversion before implant placement
- Specific prosthetic components developed for the conversion procedure (see Fig 10-2)

In contrast to the preceding option, in this protocol the prosthodontist attaches the removable denture to the provisional cylinders at chairside (see Fig 10-3f). After a single but lengthy appointment, the patient can leave the office wearing a new fixed provisional prosthesis.

The prosthodontist creates generous openings in the removable denture at points facing the implants, so that the provisional cylinders can pass through it (see Fig 10-3c). The titanium cylinders are screwed into the implants, and the prosthesis is attached to them with acrylic resin.

The time required for osseointegration of the implants is at least 2 to 3 months for healed sites and 3 to 4 months for extraction sites. After the successful osseointegration of all the implants has been verified, the screw-retained final prosthesis is fabricated in the usual fashion: The prosthodontist takes an impression, the laboratory makes the prosthesis, and the clinician places it in the patient's mouth and adjusts the occlusion.

Advantages

- The patient's psychologic needs are satisfied because the patient is provided with a restoration promptly after surgery.
- Precise coordination with the laboratory is not needed.
- Unlike the option that provides an immediate final prosthesis, this option allows the clinician to manage implant failure with relative ease.

Disadvantages

- The patient must sit through a long appointment. Because the prosthetic phase commences immediately after the surgical procedure, the patient must endure 3- to 5-hour sessions in the dental chair.
- Both practitioners and the chairside assistants must work through the protracted sessions. This is especially the case when the same practitioner performs both the surgical and the prosthetic phases.
- The patient's costs are increased because the prosthodontist attaches the provisional prosthesis to the cylinders at chairside. The patient has to be billed for expensive chair time instead of less costly laboratory time.

Treatment tip:

This treatment option is not recommended as a first choice because it is painstakingly time consuming for both the patient and the treatment team. It is indicated when the prosthodontist does not wish to be burdened with a demanding interaction with the laboratory.

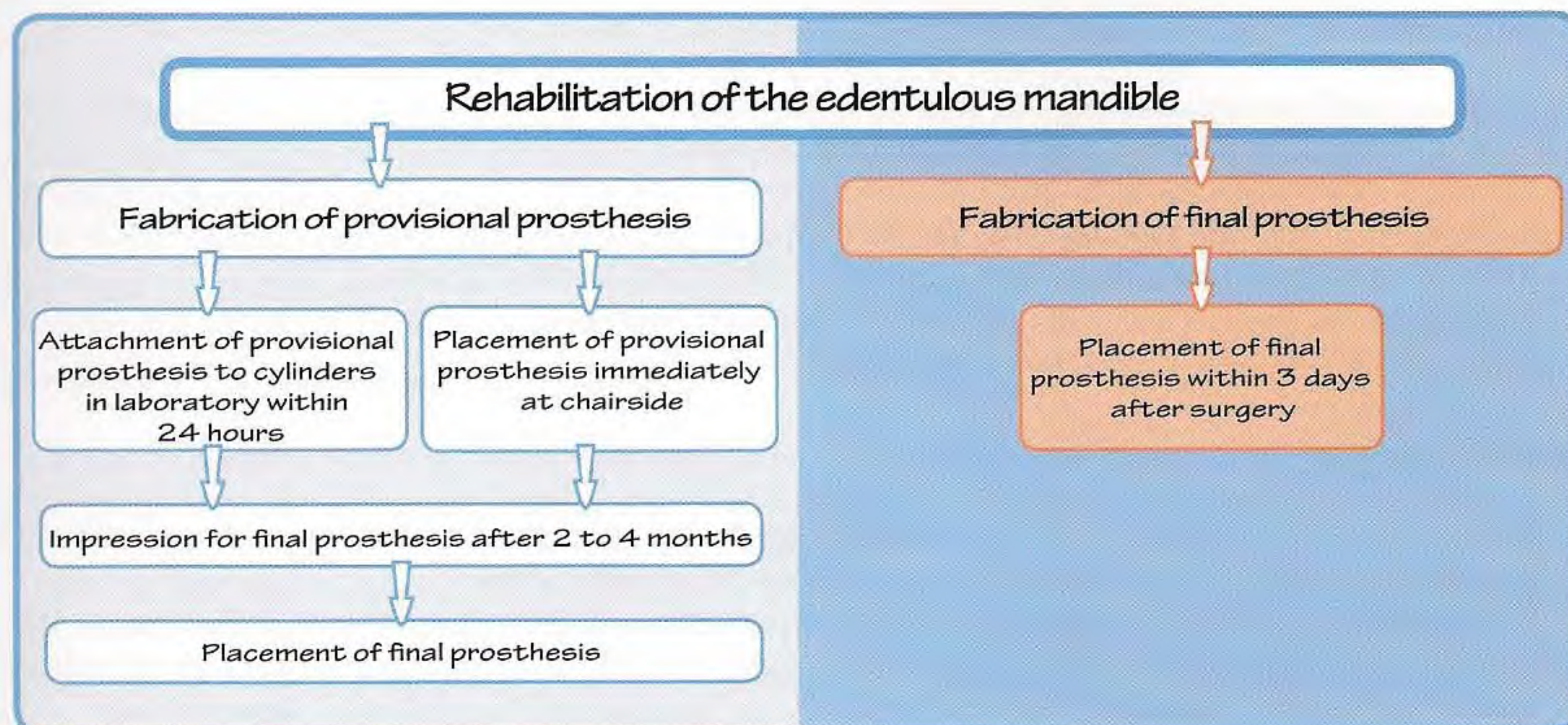
The prosthodontist should avoid utilizing the preexisting removable denture for the conversion prosthesis. Fabrication of a new denture for this procedure is more reliable. The supplementary cost imposed by fabrication of a new denture is relatively modest in comparison with the overall fee. Because this new appliance is designed to be attached to the cylinders, the buccolingual dimension should be wider than normal. This will prevent the prosthesis from breaking at the generously hollowed spaces while the opening for the cylinders is fitted.

Treatment option 3

Fixed screw-retained final prosthesis; the prosthesis is fabricated in the laboratory and placed within 72 hours after surgery.

This option (Fig 10-4d) is chosen when:

- One principal determinant of treatment is financial, for the patient who needs to keep the costs as low as possible.



▲ **Fig 10-4d** Treatment option to rehabilitate a mandible that is edentulous or becoming edentulous when the principal determinant of treatment is financial or a need to keep over-all treatment time as brief as possible.

- Another principal determinant of treatment is treatment duration, for the patient who needs to have as brief a treatment time as possible.
- The implants' axes permit the screw access path to emerge on the lingual surface in the anterior segment and on the occlusal surface in the posterior quadrants, or even more lingually, at a distance from the teeth. This option is appropriate in the mandible for healed, extraction, and mixed implant sites.

Option 3 is applicable only when micromovements have been successfully minimized (see chapter 4) and especially when all the implants have demonstrated excellent primary stability with insertion torque greater than or equal to 45 Ncm.

In this option of prompt construction, the final prosthesis can be supported by 5 to 6 implants positioned in the anterior segment of the mandible (see Fig 10-31) or 7 to 8 implants placed in both anterior and posterior regions (see Fig 10-30) or in the posterior segment only (see Fig 10-32).

Because no fee has to be charged for a provisional prosthesis, the overall treatment fee can be reduced as well. To begin fabrication of the prosthesis, the prosthodontist takes a pick-up impression and a wax bite registration of the relationship between maxillary and mandibular teeth and sends them to the laboratory. The laboratory casts a metal frame with holes that fit the transgingival abutments or directly on the implant necks. Acrylic resin or ceramic teeth are mounted on the frame. In this protocol, the patient is deprived of teeth for the 2 or 3 days that it takes the laboratory to fabricate the prosthesis. A 3-day delay should be considered the upper limit of what is allowable under the immediate-loading protocol.

For patients who have been edentulous for any length of time, an additional delay of 2 to 3 days without a prosthesis is unlikely to cause them any psychologic or functional distress. They should be able to wait a few more days without stress before receiving their new prosthesis if this approach will reduce the overall cost as well as the overall duration of treatment.

For patients who are about to undergo the trauma of extraction of their last remaining teeth, the bleak prospect of becoming edentulous will be brightened by the prospect of soon being able to face the world wearing a permanent fixed prosthesis.

Advantages

- The comfort of the patient is respected, because only the surgical phase is endured. The 1- to 3-hour prosthetic phase in the chair is avoided.
- Overall treatment time is reduced. Within 3 days, the patient receives the final fixed prosthesis.
- The treatment is easier for the prosthodontist, who is spared from tedious and protracted chair time.
- For the prosthodontist, chair time is freed for treatment of other patients.
- Because the provisional prosthesis has been eliminated and chair time has been decreased, the cost to the patient can also be lowered.

Disadvantages

- The patient has to wait 2 or 3 days after surgery to receive the prosthesis.
- The risk of failure of the final prosthesis is not entirely eliminated.
- In the event of implant failure, the final prosthesis will require extensive adjustment. The additional costs incurred during these revisions may be as great as the amount saved by avoiding the provisional prosthetic stage.

Treatment tip:

This treatment option is recommended only if:

- The practitioner is experienced with immediate-loading procedures.
- The implants have achieved good primary stability.
- A good, accurate impression can be taken.
- The laboratory is experienced in the rapid construction of reliable metal frameworks.
- Both the patient and the practitioner are prepared to take a financial risk.

▼ Step-by-Step Guidelines for Immediate-Loading Treatment of the Edentulous Mandible

Indications

- Available bone height at the implant site: ≥ 10 mm
- Available bone width at the implant site: ≥ 5.5 mm
- Bone quality: dense or normal (types 1 to 3)
- Number of implants: 5 to 8
- Insertion torque of each implant: ≥ 35 Ncm

Contraindications

- If implants demonstrate inadequate primary stability, the immediate-loading protocol must be discontinued.
- Patients who exhibit bruxism are not good candidates for immediate loading.

Specific considerations for treatment of the edentulous mandible

Surgical considerations

- Parallelism between anterior implants must be respected so that there will be no divergence of the screw access paths on the lingual or occlusal surfaces of the prosthetic teeth. This would make attachment of the prosthesis to the cylinders at chairside difficult or impossible.
- The surgeon does not have to comply with the strict rules of implant positioning because there are no esthetic considerations. Biomechanical considerations prevail over esthetics.
- If a complete-arch prosthesis is contemplated at a later time, implants should not be placed in the embrasures between two crowns of the future restoration.

- In the edentulous mandible in which all the sites are healed, the surgeon can expect almost all implants to achieve good primary stability.
- In a mandible that will be edentulous after extraction of remaining teeth, implants are placed in the extraction sockets. Achievement of primary stability might be more demanding in these sites than in healed sites.
- In the canine extraction socket, the surgeon may have to fill the gap left between the implant and the buccal plate.

Prosthetic considerations

- The surgeon, in consultation with the prosthodontist, should determine the optimal transgingival abutment height that will be most compatible with good oral hygiene.
- Esthetic considerations should not play a key role.
- If an extension would be beneficial to the prosthetic design, the prosthodontist should determine its length in consideration of the anteroposterior distance rule (see Fig 4-9).
- When the indirect laboratory-fabrication method is chosen (option 1), creation of an accurate and effective impression will require time and scrupulous attention to detail. Precise collaboration with an experienced laboratory is crucial.
- When the direct chairside fabrication method is chosen (option 2), the prosthodontist should bear in mind that the work at the chair will be long and demanding as well as fatiguing for the patient.
- When a final prosthesis is to be delivered to the patient immediately (option 3), the laboratory should be experienced in the rapid and reliable fabrication of a metal frame.

Surgical phase: Case reports

The treatment options and the prosthetic phase for the mandible that is edentulous and the mandible that is becoming edentulous are identical; only the surgical phase differs. Therefore, each surgical situation will be illustrated by a case. Then, the prosthetic options will be presented, any of which can be selected after either surgical procedure.

Replacement of the complete dentition in mandibular healed sites

Presurgical preparation

Clinical examination

- Determination of the smile line (Fig 10-5a).
- Clinical evaluation of the height and width of the alveolar ridge (Figs 10-5b and 10-5c).
- Evaluation of the removable denture the patient is currently wearing to determine whether it can serve satisfactorily as the basis for the fixed provisional prosthesis. In this case, it was decided to make a new denture because the acrylic resin teeth of the existing prosthesis were severely abraded (Fig 10-5d).
- Evaluation of the prosthetic space available for a new prosthesis.

Radiographic examination

The height and width of the alveolar ridge are evaluated with a panoramic radiograph (Fig 10-6a) and/or computerized tomography (CT) (Figs 10-6b to 10-6d). The CT scan is indicated because it provides a clear picture of the concavities and bone defects in the alveolar ridge (see Figs 10-6c and 10-6d) as well as the anatomic structures that must be accommodated. Furthermore, from the anatomic picture the CT scan provides, the practitioner can predict any specific difficulties that may arise during implant placement.

For immediate loading, optimal conditions for implant placement should be met so that the clinicians can effectively concentrate on the prosthetic stage of the treatment. Errors in estimating the available osseous envelope, which are usually minor and of little consequence for conventional implant loading, can conceal flaws that will prove fatal to immediate loading, for example, when it is difficult to obtain primary stability of 35 Ncm or greater, as can happen after the implant encroaches on the buccal plate.



▲ **Fig 10-5** Pretreatment clinical examination. (a) Determination of the smile line. (b) Evaluation of the available ridge height. (c) Evaluation of the available ridge width. (d) Evaluation of the patient's current removable denture. The prosthesis is severely worn and cannot be used as a fixed provisional prosthesis.

Study casts: Preparation of the surgical guide

The surgical guide is designed to conform to the prosthetic requirements; it helps the surgeon to position implants with precision.

In uncomplicated cases, where the crest is large, the surgeon is experienced, and esthetics is not a primary factor, the surgical guide is not restrictive; it does not have to determine exact implant positions (Fig 10-7). When implant placement requires precision, however, the surgical guide is restrictive; it has to accurately define the mesiodistal and buccolingual axes of the implants.

Surgical phase

Placement of implants

Selection of implant design and number of implants. While preparing the case, the surgeon can choose among various implant designs, including standard parallel-walled, conical, or wide-neck implants with internal or external connections. For the present case, the simplest implant was used, because any type should have been able to ensure good primary stability.

Five implants are often sufficient; in this case, six were used. When anterior implants cannot be placed, a greater number of posterior implants, as many as eight, are indicated to provide a good supporting base for the entire length of the provisional prosthesis. This can be achieved only with a supporting metal frame (see Fig 10-32e).

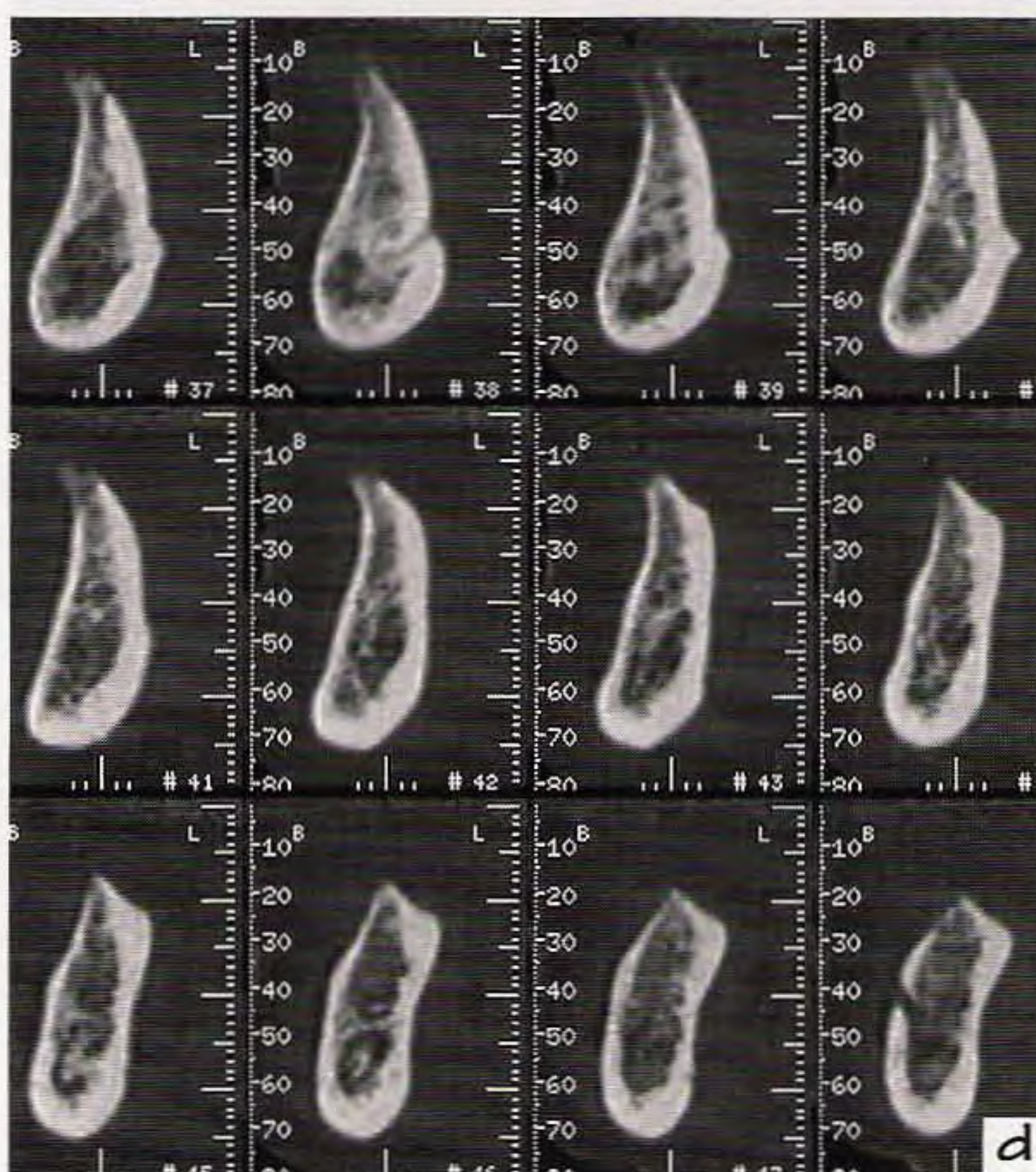
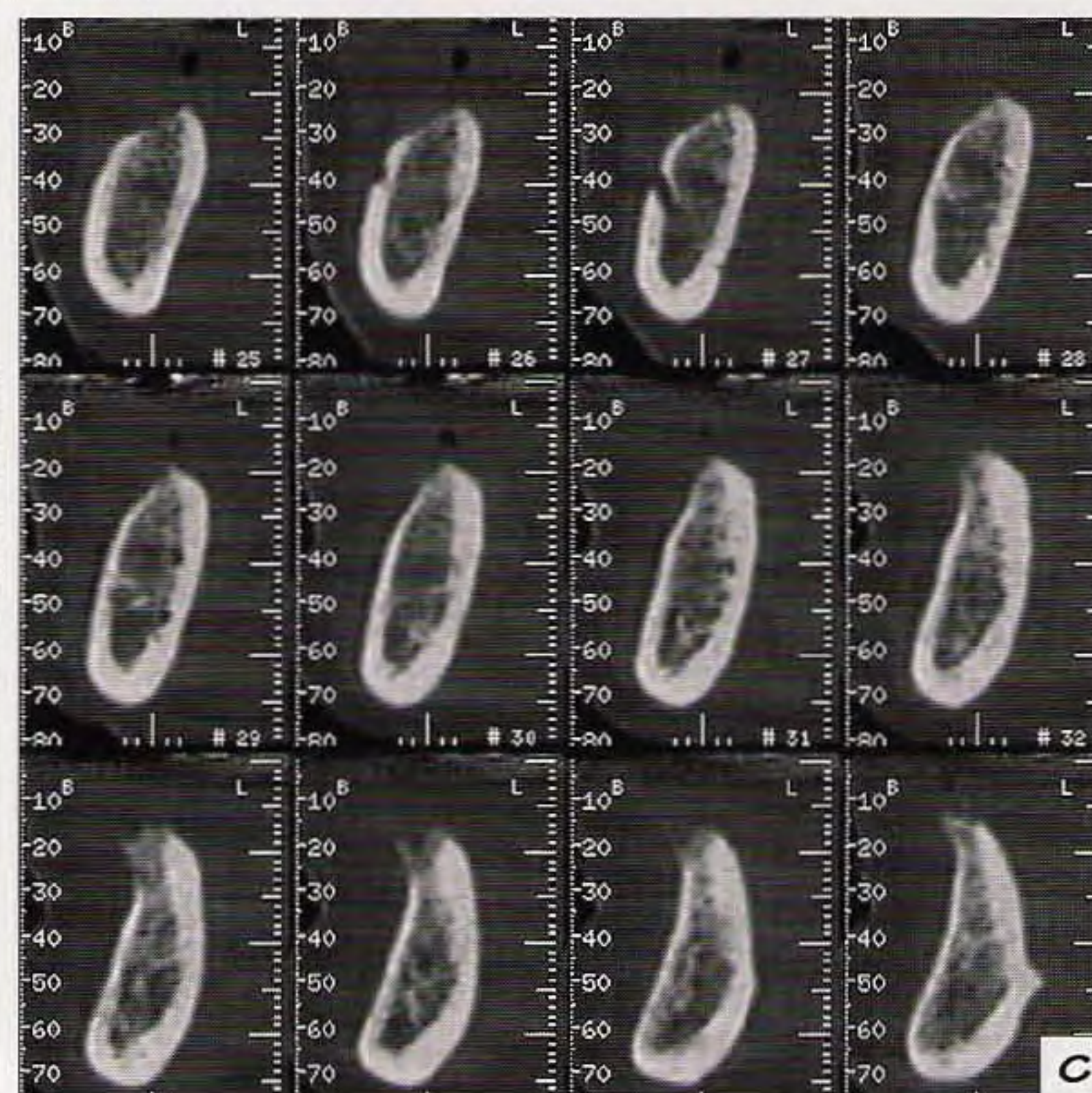
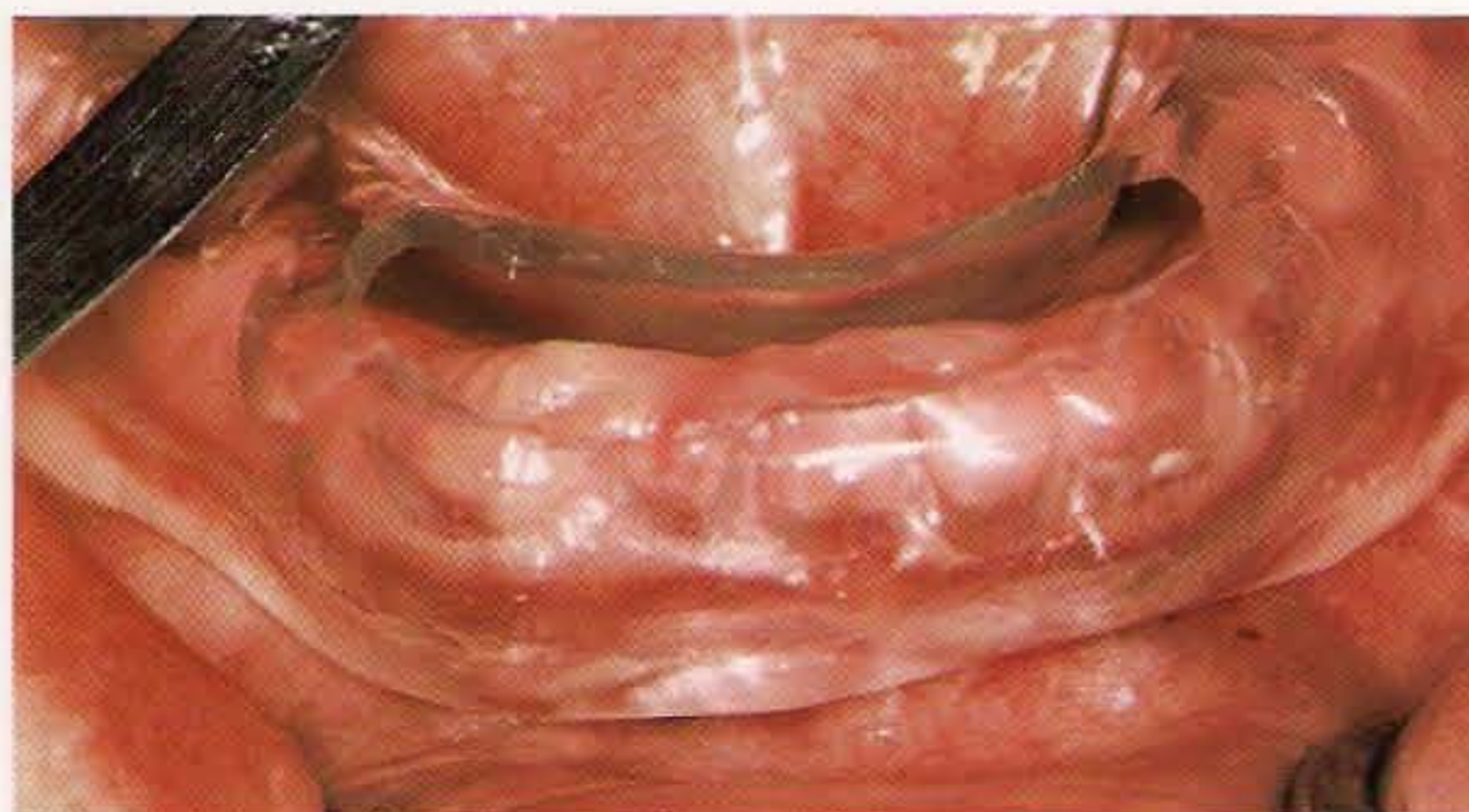
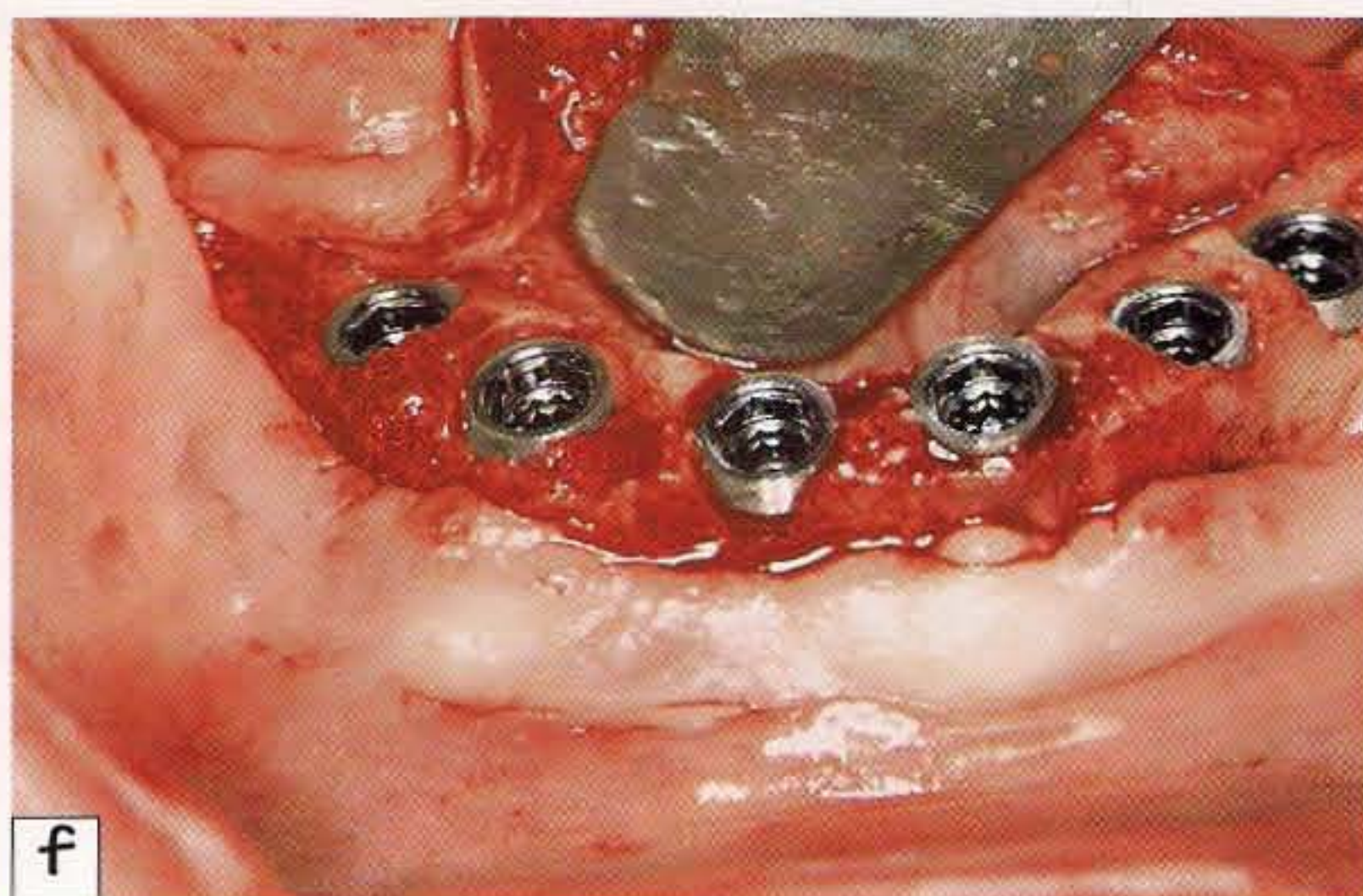
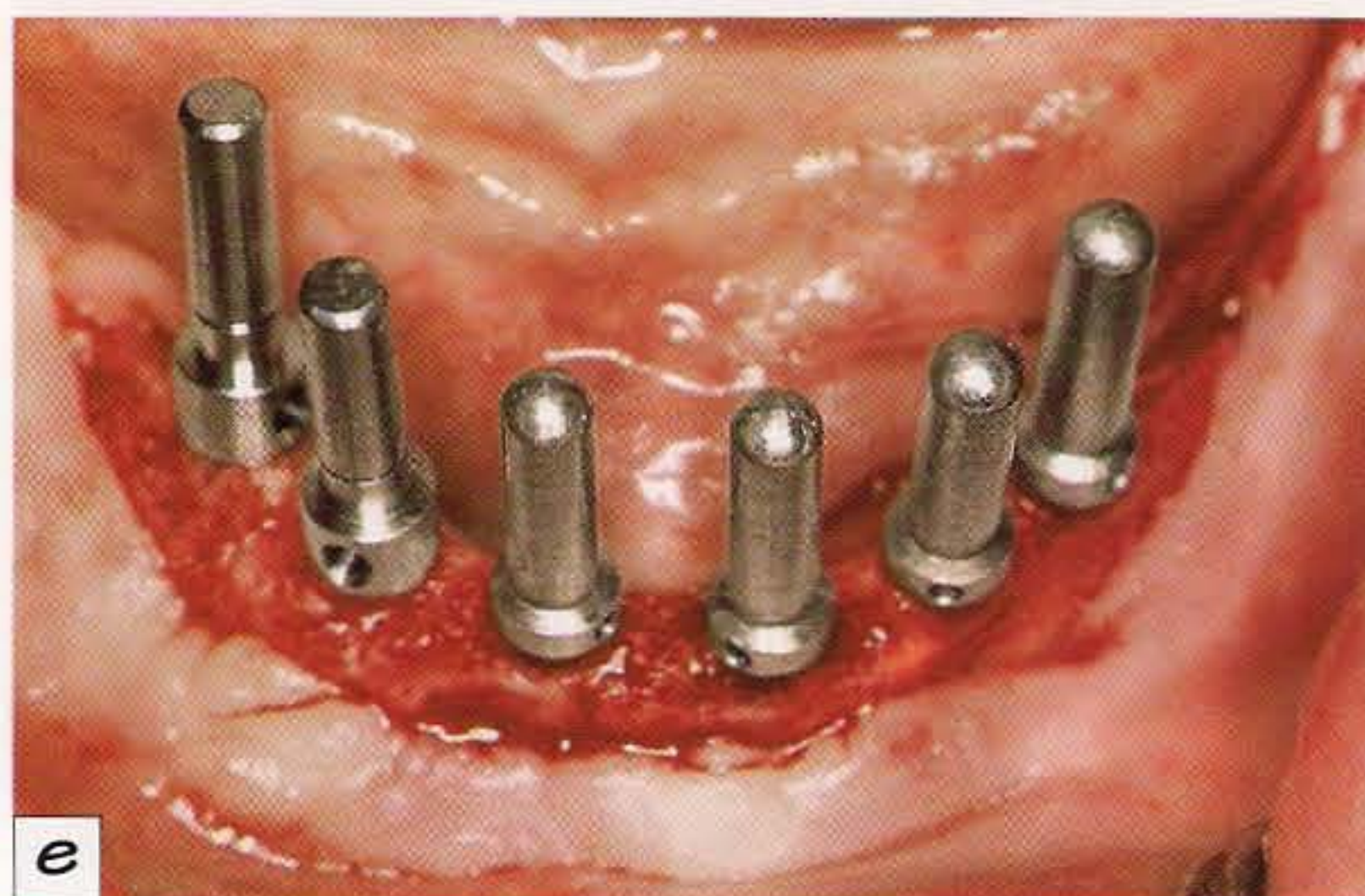
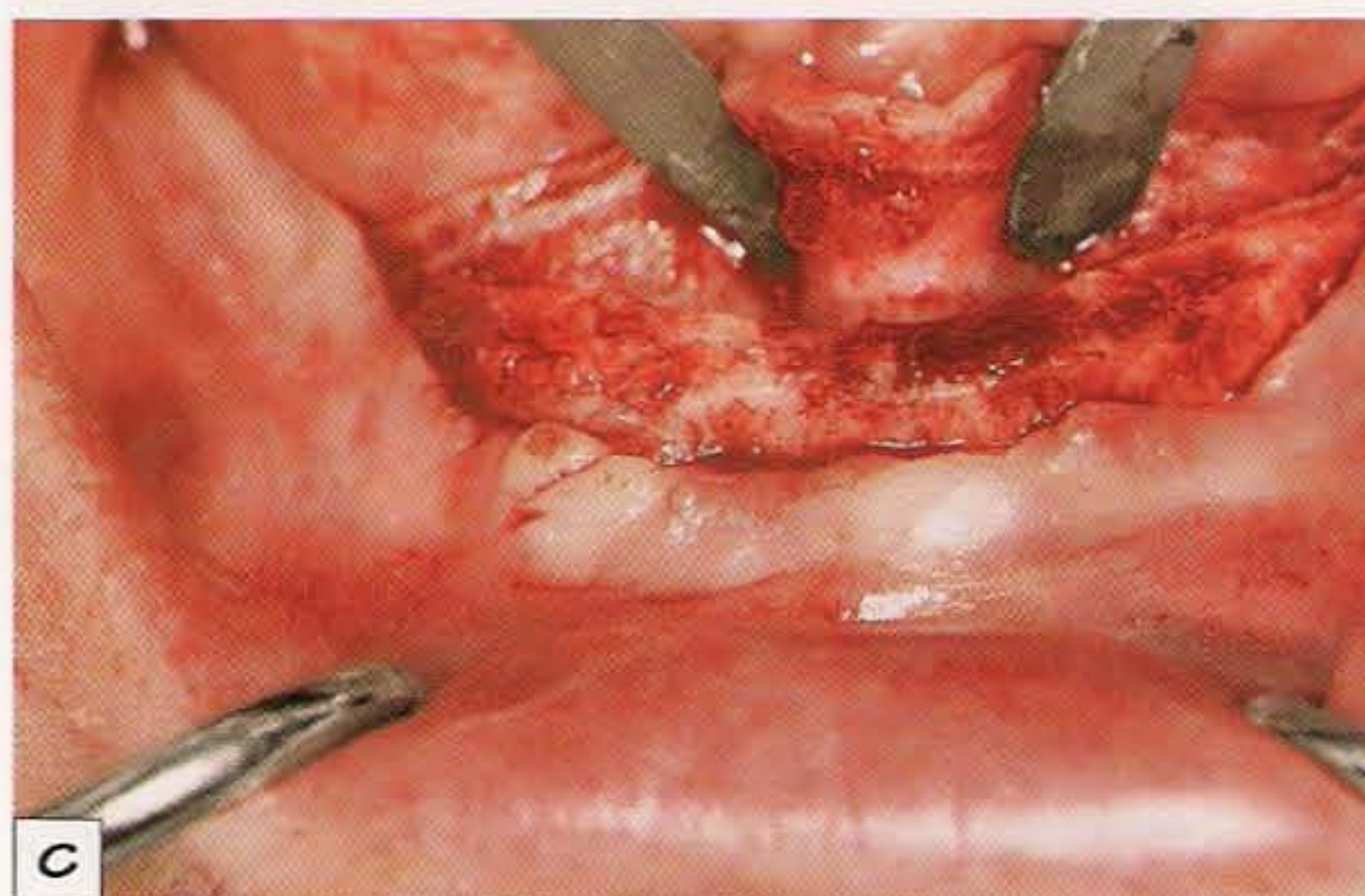
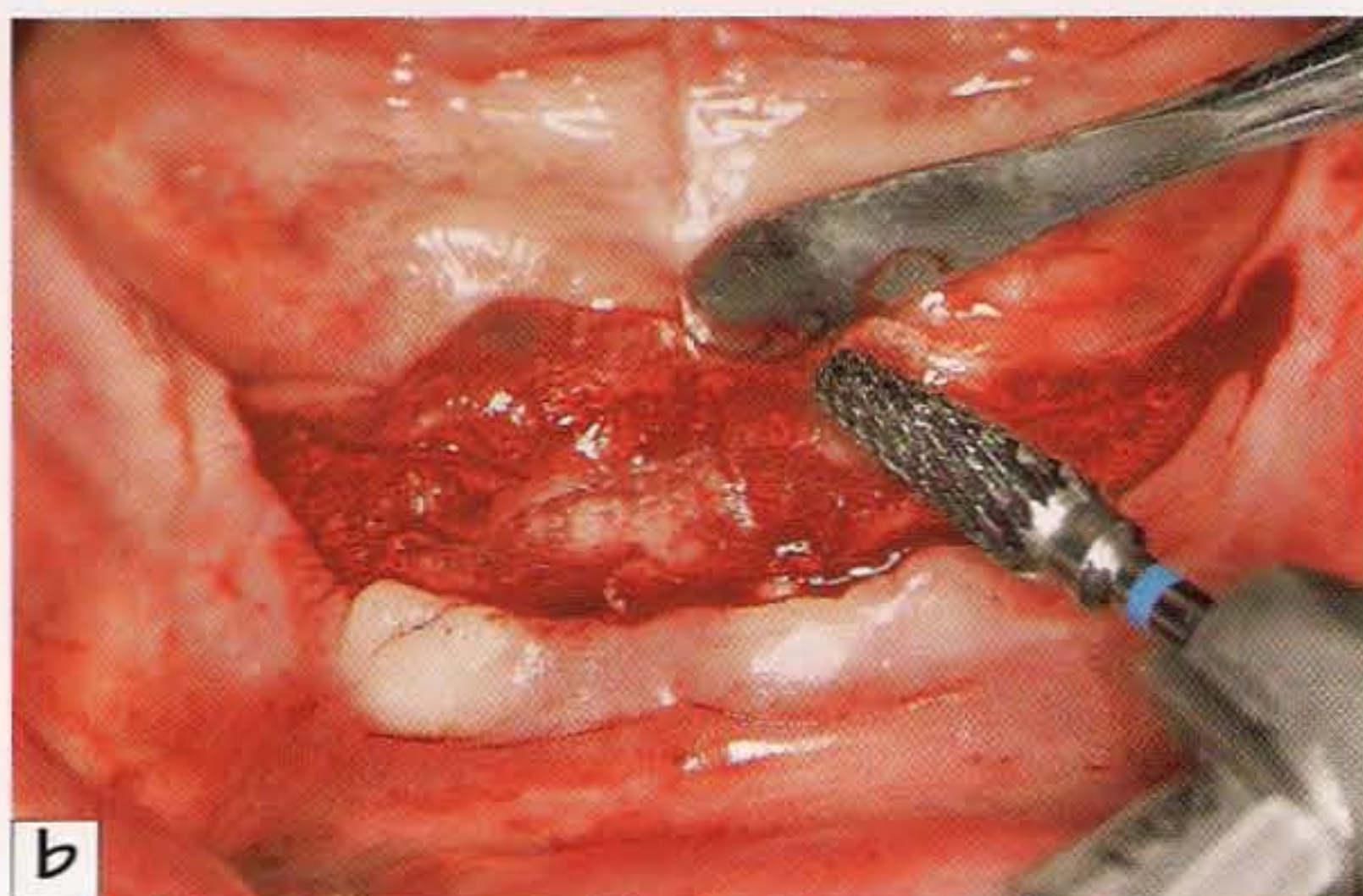


Fig 10-6 Pretreatment radiographic examination. (a) Panoramic radiograph. Bone is abundant in the anterior area and deficient in the posterior quadrants. (b) CT scan of the mandible (axial view). Below the alveolar ridge, mandibular bone width is adequate for implant placement. (c) CT scan (first series of oblique axial sections between the mental foramina). These views reveal the absence of concavities but also the reduced width of the ridge in the anterior segment. (d) CT scan (second series of oblique axial sections between the mental foramina). These views confirm the previous observation of reduced alveolar ridge width. The anterior ridge should be reduced in height until it reaches a level where the bone width is sufficient to receive implants.

Preparation of osseous sites. The surgeon makes a crestal incision and raises a full-thickness flap to provide good visibility of the bony landmarks (Fig 10-8a). In this case, the osseous crest had to be flattened to increase the bone width and to allow all implants to be placed at the same level (Figs 10-8b and 10-8c).

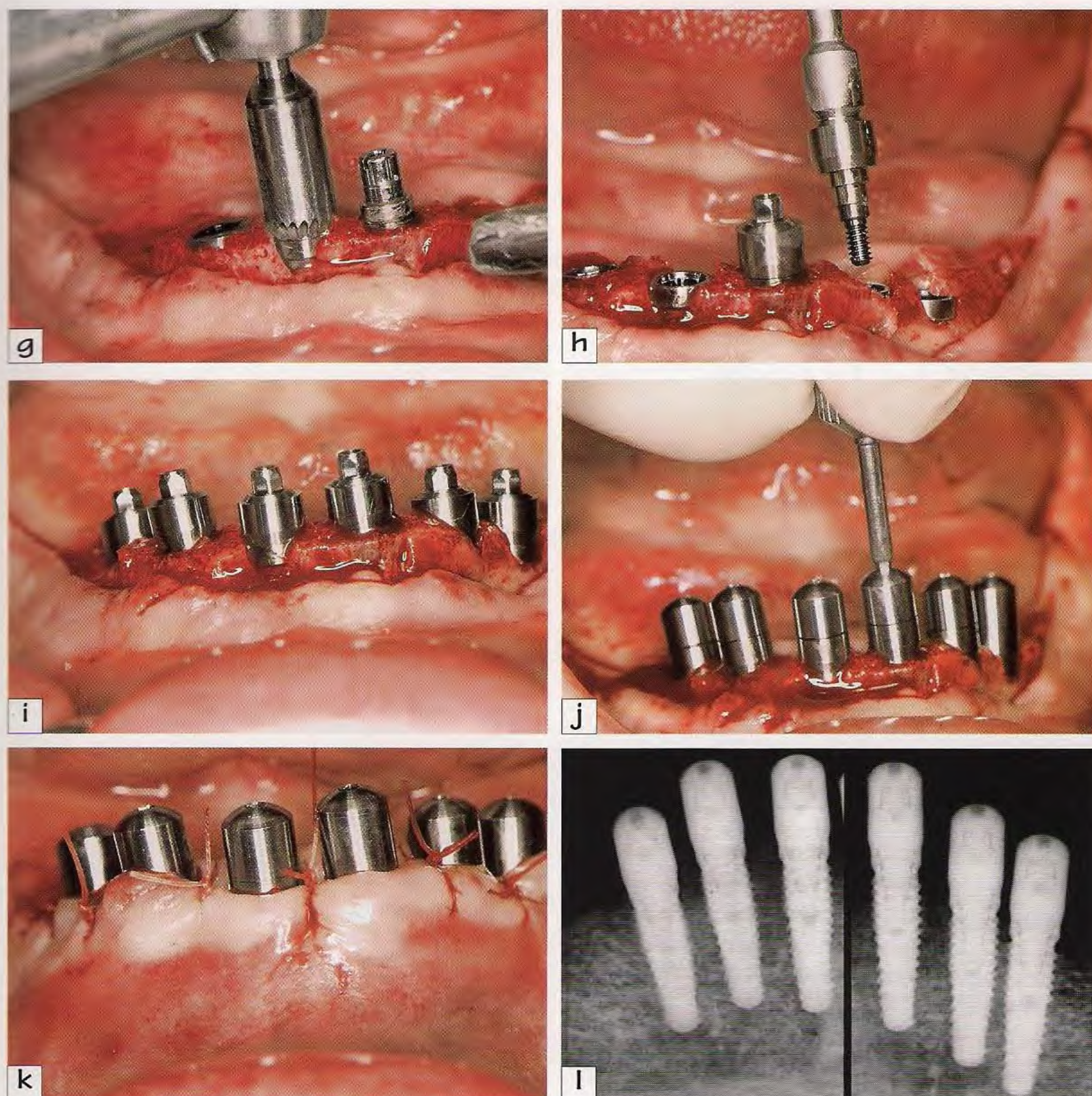


◀ **Fig 10-7** The surgical guide is not restrictive because the case is uncomplicated.



The surgeon prepared the central sites first (Fig 10-8d), then the most distal sites, and finally the sites between those extremes.

Drilling sequence. The classic drilling sequence was followed because bone density was normal or type 2. Had the bone been dense, the surgeon would have included the screw-tapping step to avoid overheating the bone during implant placement.



◀ ▲ **Fig 10-8** Surgical phase. (a) Crestal incision. (b) Leveling of the anterior alveolar ridge to increase bone width for implant insertion. (c) Leveled bone crest. (d) Preparation of the anterior implant site. (e) Verification of the mesiodistal and buccolingual axes as well as the parallelism of the implants. (f) Seated implants. All possible vertical implant positions, supracrestal, subcrestal, and level with the crest, have been used because the main goal is to achieve adequate primary stability. (g) Use of the bone profiler. The guide pin of the bone profiler is in place on the implant on the right side, while the bone profiler is in position on the implant on the left side. (h) Placement of IOL transgingival abutments for implants with an internal connection. (i) Clinical view after placement of all transgingival IOL abutments. (j) Placement of the healing caps, which will be tightened later. (k) Clinical view after suturing. (l) Postoperative control radiographs.

Three-dimensional (3D) positioning. The mesiodistal axis was perpendicular to the bone crest (Fig 10-8e). The buccolingual axis conformed to the axis of the crest. Under optimal conditions, the emergence points of the implants at the crest leave at least 2 mm between the external edge of the implant and the external edge of the buccal plate. However, this requirement did not have to be satisfied in this case because esthetics was not a primary consideration.

Direction indicators placed in all the sites indicate the extent of parallelism, which in this case was satisfactory (see Fig 10-8e).

The vertical positioning of implants should be either supracrestal or level with the crest because esthetics considerations are not relevant in this indication. Subcrestal positioning is also permissible if it increases primary stability. All three possibilities are represented in Fig 10-8f.

Primary stability. Insertion torque, Osstell (Osstell), or Periotest (Medizintechnik Gulden) measurements provide information about the level of primary stability. Clinicians can safely assume that the insertion torque reflects a good approximation of the primary stability that can be obtained at a given site.

This insertion torque should measure 35 Ncm or more for all implants. Set at 30 Ncm, the handpiece should stall before the full seating of the implant, which is then completed with the torque raised to at least 40 Ncm. Good primary stability is especially required for the most distal and most anterior implants.

Use of bone profiler. The guide pin is screwed in the implants and then the bone profiler is seated on the guide pin for removal of the bone around the implant neck (Fig 10-8g). This procedure is indispensable when the implant is in a subcrestal position. It guarantees good seating of the abutment on the implant neck.

Selection of abutments. Healing or transgingival immediate occlusal loading (IOL) abutments are placed at this stage, before suturing. These prosthetic parts are placed by the surgeon, which means that the surgeon must order them before surgery, after having agreed on their dimensions with the prosthodontist.

Depending on the prosthetic option selected, the surgeon will position either transgingival IOL abutments (Figs 10-8h and 10-8i) and their healing caps (Fig 10-8j) or healing abutments (see Fig 10-32c).

Suturing. The surgeon closes the mucosa with simple sutures (Fig 10-8k).

Control radiograph. Panoramic or periapical radiographs are taken to evaluate implant placement (Fig 10-8l). They will also serve as a baseline against which the clinician can evaluate the status of the bone crest over time.

Transition from surgical treatment site to prosthetic treatment site. This critical phase, which may appear trivial, is important to patients, who need to be reassured that the treatment team is focused on serving them. This transition is also a good indicator of how well coordinated the practitioner team is.

Before the various prosthetic options available to treat this indication are discussed, surgical management of a mandible that is becoming edentulous is presented.

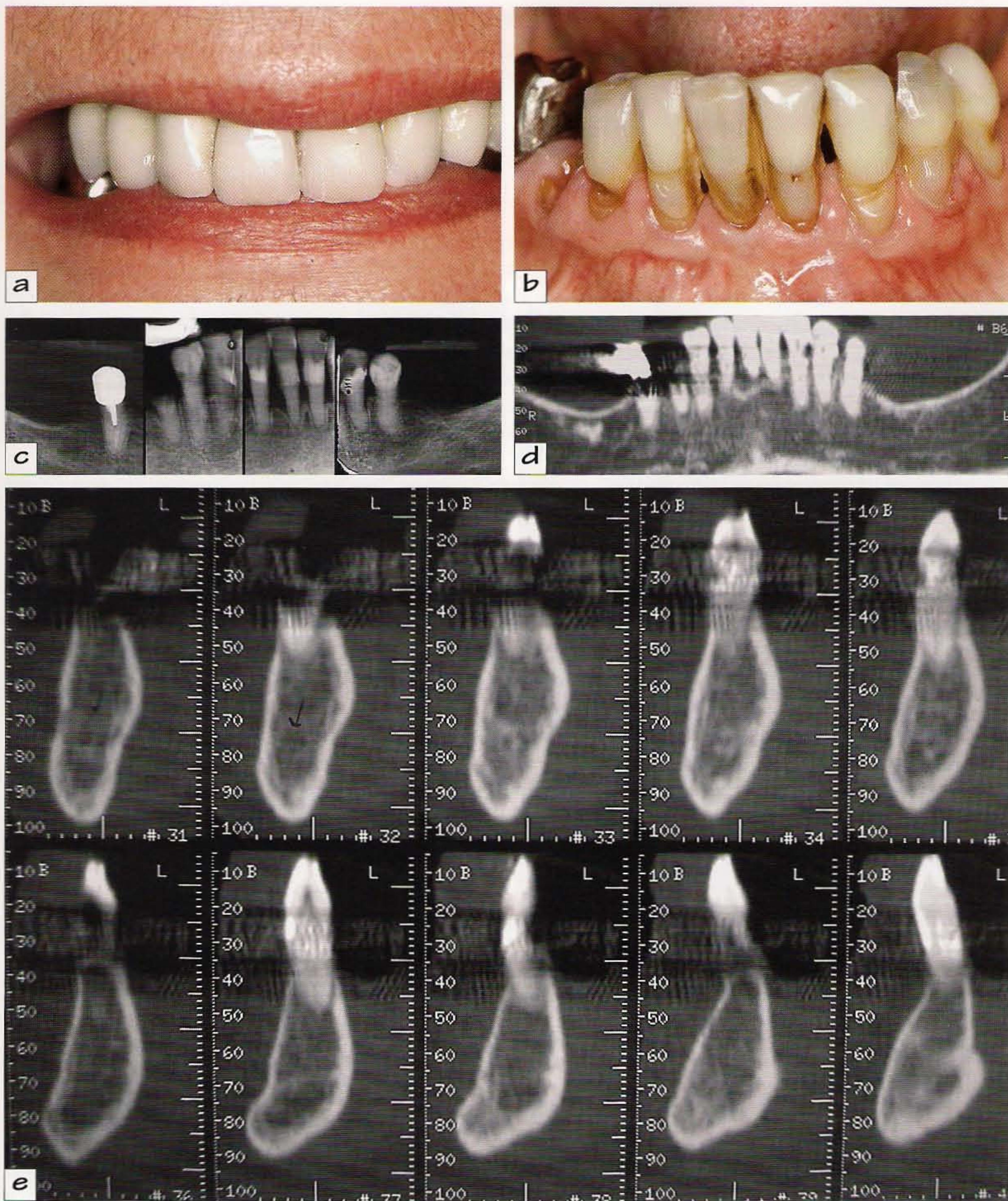
Replacement of the complete dentition in mandibular extraction sites

A woman who was missing many mandibular teeth sought total rehabilitation of her mandible. Because of advanced periodontal disease, the remaining teeth, incisors, canines, and first molars, had to be extracted. The patient wanted treatment to be completed as quickly as possible.

Presurgical preparation

Clinical and radiographic examinations

- Determination of the smile line (Fig 10-9a)
- Evaluation of the periodontal status of the teeth to be extracted and the possible presence of infection sites (Figs 10-9b and 10-9c)
- Diagnosis that dictates extraction of all remaining teeth (see Figs 10-9b and 10-9c)
- Determination of the height and width of available crestal bone for implant placement with a CT scan (Figs 10-9d and 10-9e)



▲ **Fig 10-9** Presurgical clinical examination. (a) Determination of the smile line. (b) Clinical evaluation of the status of the remaining teeth. (c) Radiographic evaluation of the status of the remaining teeth. Advanced bone resorption is visible at the anterior teeth. (d) CT scan of the mandible (panoramic reconstruction). (e) CT scan of the mandible (oblique axial sections between the two mental foramina) reveals no concavities and the presence of adequate bone height.

Study casts: Preparation of the surgical guide

A surgical guide without precise implant positioning is prepared. It will allow the surgeon to adapt to whatever specific osseous situations the advanced periodontal disease may have created (Figs 10-10a and 10-10b).

Surgical phase

Extraction of teeth with poor prognosis

Before the teeth are removed, the clinician carefully removes tartar from the root surfaces and orders a course of antibiotic therapy to begin 3 days before the surgery. Although the radiographic examination in this case (see Fig 10-9c) showed that one or two teeth could be retained, all mandibular teeth were extracted to permit the fabrication of a complete-arch implant-supported prosthesis. The surgeon removes the teeth atraumatically, being careful to conserve the buccal cortical plate as much as possible. In this patient, all implants were placed in extraction sites between the foramina (Fig 10-10c).

Placement of implants

Selection of implant design and number of implants. As in the previous case, any implant could be used according to the surgeon's inclination, because any type should easily obtain good primary stability.

In some situations only five anterior implants are required, but for this case it was decided the prosthesis should be supported by eight 4- and 5-mm-diameter implants placed in anterior and posterior segments (see Fig 10-10c).

Access to bony sites. Access can be obtained directly through the socket without raising a flap or after raising a flap. Placement of an implant without flap elevation is possible when the CT scan shows no concavities or other specific osseous obstacles (see Fig 10-9e). A flap is elevated when anatomic obstacles are present or when a large gap around an implant must be filled with a bone substitute material. Good visual access to the anatomic structures is a surgical necessity for these cases. Figure 10-11 illustrates a case where a flap was raised to fill the gap that remained after implant placement in a large canine socket.

Drilling sequence. The classic drilling sequence was followed in this case because the bone type was normal. The socket was drilled 3 to 5 mm beyond its apical limit to increase primary stability. The central sites were prepared first, the most distal sites were prepared next, and the sites between the two extremes were prepared last. Parallelism of the implants was checked by placing directional indicators in all the prepared sites.

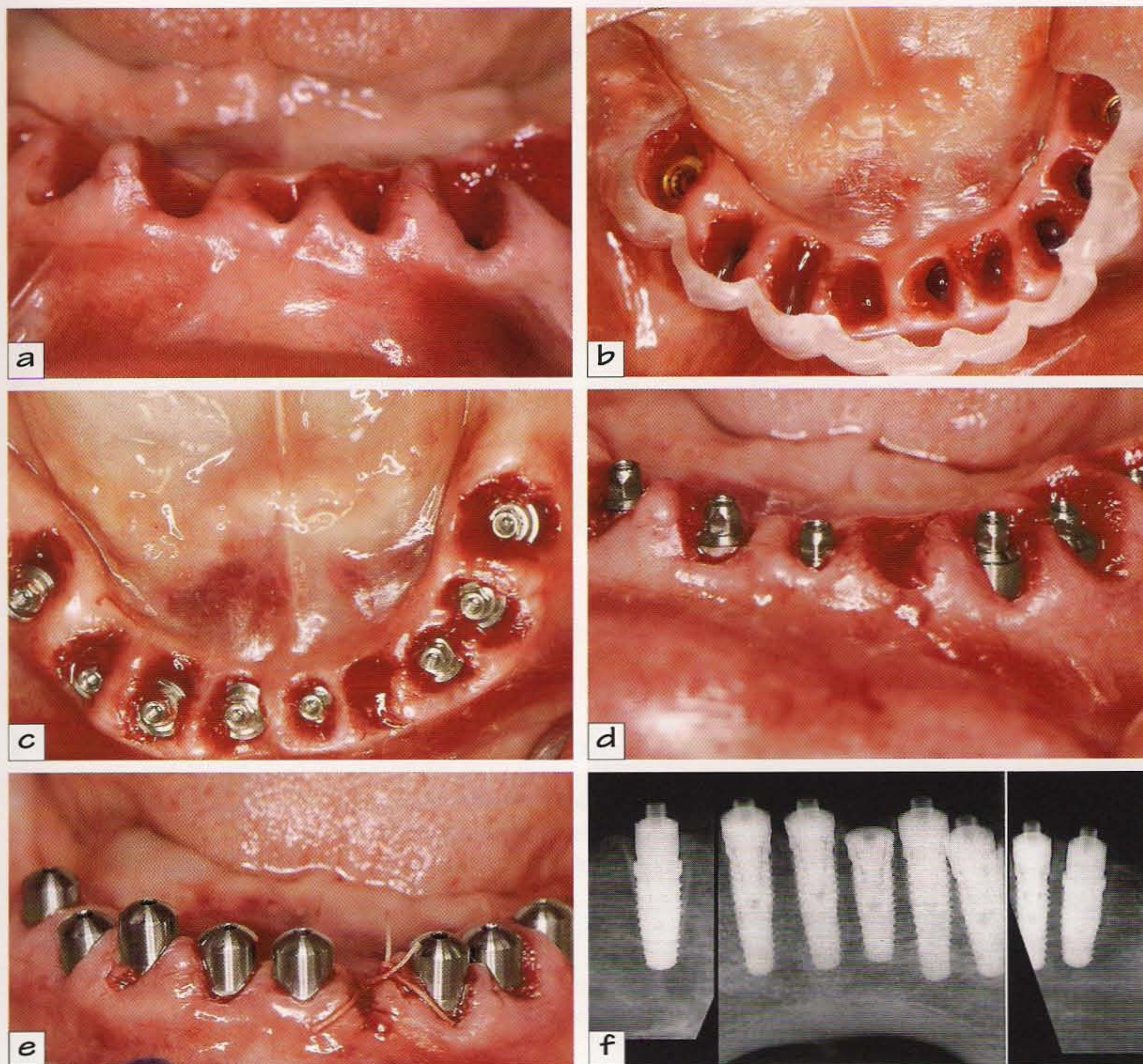
3D positioning. The mesiodistal axis is specified by the surgical guide (see Fig 10-10b); in this patient, it coincided with the alveolar axis. The surgical guide is also used to establish the buccolingual axis, which controls the buccal envelope of the planned rehabilitative prosthesis. The buccolingual axis also generally follows the alveolar axis or is lingual to it.

Implants are, preferably, placed supracrestally or level with the crest. They can also be placed subcrestally, as was the case in the previously described healed edentulous mandible, where a variety of osseous configurations were encountered (see Fig 10-8).

When a flap is not raised, the surgeon places the implant in a blind technique in which no landmark is visible. A graduated implant driver tip helps to place the implant neck 3 mm below the marginal gingiva.

Primary stability. The insertion torque should be greater than or equal to 35 Ncm for all implants, especially for the central and most distal implants.

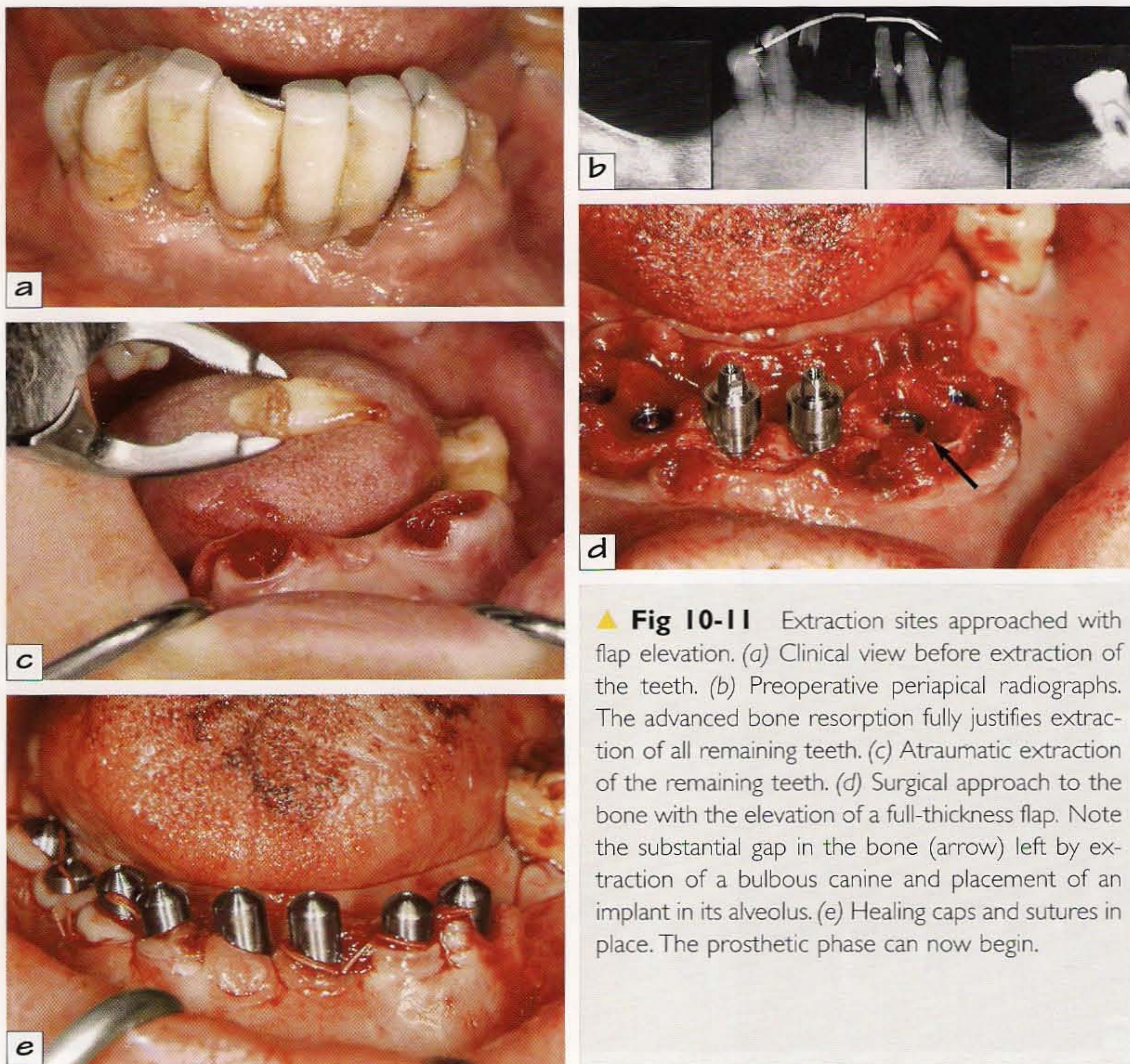
Use of bone profiler. The use of this instrument is indispensable for the perfect seating of the abutment on the implant neck when the implant is completely or even partially subcrestal.



▲ **Fig 10-10** Surgical phase. (a) Clinical view after the atraumatic extraction of all remaining teeth. (b) Nonrestrictive surgical guide in place. Implants have been positioned without elevation of a flap. (c) Implants and transgingival IOL abutments placed in the alveoli of the extracted teeth. Two implants have been placed distal to the foramen, in the alveoli of premolars. (d) Buccal view of the IOL abutments. Note the location of the top of the abutments; the abutment-prosthesis junction will be located gingivally or supragingivally. (e) Clinical view after placement of the healing caps. The gingival site where no implant is located has been sutured. (f) Control radiographs. Note the implants with the transgingival abutment and the one left unloaded to receive a healing cap. For teaching purposes, the titanium IOL abutments have been left uncovered, without their healing caps, so that they could be clearly visualized on the radiograph.

Selection of abutments. Transgingival abutments are placed during the surgical phase, before suturing (Figs 10-10c and 10-10d). These prosthetic components should be preordered and ready, at hand, for the surgeon's use.

Healing caps are screwed in the transgingival abutments (Fig 10-10e). They should be placed even if the patient does not have to move from one office to another after surgery to start the prosthetic phase. The healing caps help to keep the gingiva in place and prevent it from collapsing. They continue this function when the prosthesis has to be removed from the mouth and replaced during the various steps for attaching the prosthesis to the provisional cylinders (see options 1 and 2 of the prosthetic treatment, Figs 10-15 and 10-26).



▲ **Fig 10-11** Extraction sites approached with flap elevation. (a) Clinical view before extraction of the teeth. (b) Preoperative periapical radiographs. The advanced bone resorption fully justifies extraction of all remaining teeth. (c) Atraumatic extraction of the remaining teeth. (d) Surgical approach to the bone with the elevation of a full-thickness flap. Note the substantial gap in the bone (arrow) left by extraction of a bulbous canine and placement of an implant in its alveolus. (e) Healing caps and sutures in place. The prosthetic phase can now begin.

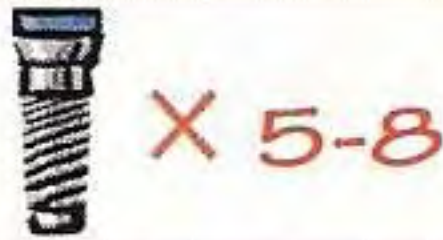
Suturing. When the alveoli are filled with an implant, its abutment, and a healing cap, they do not require sutures (see Fig 10-10e). Extraction sites that do not receive implants are closed with simple sutures.

Control radiograph. A panoramic or periapical radiograph is taken to evaluate the implant placement (Fig 10-10f). This radiograph will serve as the baseline against which the status of the bone crest can be evaluated over time.

Transition from surgical treatment site to prosthetic treatment site. The clinicians should prepare this move in advance to assure the patient that the treatment team is functioning efficiently.

Treatment variant with flap elevation

The surgical approach of choice for placement of implants in extraction sites is directly through the alveolus. In some cases, access to the osseous sites is supplemented by elevation of a flap if a CT scan has revealed the presence of anatomic obstacles or if the surgeon needs good visual access to fill in large gaps left after implant placement with bone substitute material. Figure 10-11 shows this approach. The surgeon elevated a flap because the extraction of a globular canine had left a substantial gap that required filling after implant placement.

Technical difficulty		Esthetic requirements	
Team coordination		Extra costs	
Treatment time		Risk assessment	
Number of implants		Documentation	

▲ **Fig 10-12** Key information for treatment option 1.

After the surgical phase is completed, the prosthetic aspects must be considered. The three possible treatment options available for rehabilitation of an edentulous mandible will be reviewed in detail.

Prosthetic phase: Treatment option 1

Screw-retained provisional prosthesis placed within 24 hours after surgery; the prosthesis is attached to the provisional cylinders in the laboratory (conversion of a removable denture to a fixed prosthesis).

Reminder:

- This option is selected when the principal determinant of treatment is the comfort of the patient. The patient is reluctant to sit through a protracted, combined surgical and prosthetic appointment that could last from 3 to 5 hours.
- The treatment is carried out in two sessions of reasonable length, over 1 or 2 days.

Key information for treatment option 1

Figure 10-12 summarizes the key aspects of prosthetic treatment in accordance with treatment option 1.

Technical difficulty is average

Difficulty is considered average because the laboratory bonds the prosthesis to the cylinders and the prosthodontist is spared the burden of doing it chairside.

During the surgical phase, the implants must be placed with good parallelism, and the access holes for the screws must be sufficiently lingual to the buccal surfaces of the involved dental units.

After the clinician has taken an impression with the implants and abutments in place, the laboratory bonds the prosthesis to the cylinders. After seating the prosthesis, the clinician will have to adjust the occlusion. This task increases the technical difficulty enough to put it in the average range.

Team coordination is moderate

The prosthetic phase does not follow surgery in a single session. However, it begins immediately after implant placement when the prosthodontist takes an impression that is sent to the laboratory.

The laboratory technician starts working immediately after surgery and bonds the provisional prosthesis to the provisional cylinders. This is a relatively clear-cut procedure with few complications and no urgency because there are no critical esthetic or functional demands to satisfy. It can be easily performed within 72 hours.

Treatment time is average

The prosthetic phase does not follow immediately after surgery, whose length is unchanged. The prosthetic phase comes later and is shorter than that of option 2, where the prosthodontist attaches the prosthesis to the cylinders at chairside. The time needed for the two steps is average: 2 to 3 hours for the surgical phase and 1 to 2 hours for the prosthetic phase. The latter is divided into two stages, the first for preparation of the impression after the surgery and the second for attachment of the prosthesis to the implants and adjustment of the occlusion.

Number of implants: 5 to 8

Five to eight implants are used. Clinicians may want to use more than the average number of five or six implants used for a hybrid prosthesis if the mandible is to be rehabilitated with a complete-arch prosthesis supported on anterior and posterior implants, if bone quality is poor, or in the presence of patient risk factors such as diabetes, bruxism, and addiction to smoking.

Esthetic requirements are low or nonexistent

Because there are no esthetic concerns in most cases of complete rehabilitation of an edentulous mandible, the strict rules for 3D implant placement do not apply.

Extra costs are substantial

The provisional prosthesis requires specific, expensive prosthetic components, which cannot be reused in the final prosthesis. The laboratory can attach the prosthesis to the cylinders with relative ease, and chair time is spared. This makes it possible for costs to be reduced below the level of option 2, where the prosthodontist attaches the prosthesis to the provisional cylinders at chairside.

Additional risk is low

Obtaining primary stability, which is enhanced by the splinting effect of the immediately loaded prosthesis, should not pose any particular problem. Success rates are high and comparable with those of delayed-loading protocols.

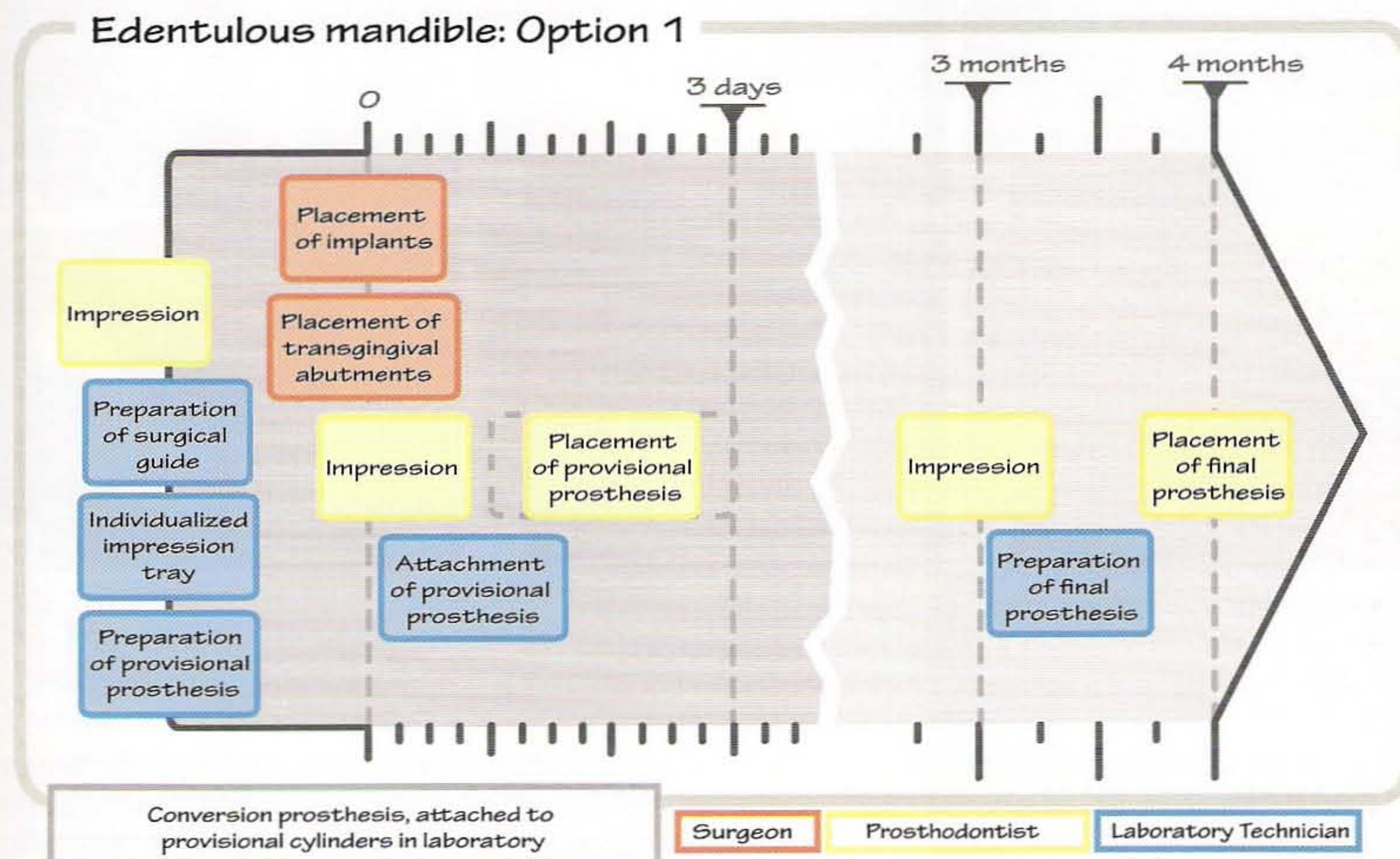
Documentation in the literature is extensive

This indication for immediate loading is the one best documented in the literature. Immediate-loading procedures that involve posterior implants are not nearly as well documented.

Sequence and timing of steps for treatment option 1

Figure 10-13 illustrates the treatment chronology for option 1:

- The laboratory participates before and after implant placement. Before surgery, the technician prepares the surgical guide, the removable denture, and the individualized impression tray. After surgery, the technician attaches the prosthesis to the provisional cylinders and finishes the preparation of the provisional prosthesis.
- The implants are placed in the usual way.
- The prosthodontist takes an impression immediately after surgery.
- The prosthodontist completes the intervention in a second distinct session that takes place 3 to 72 hours after surgery, depending on the accessibility and availability of the laboratory.
- After a 2- to 4-month period to allow osseointegration to take place, the clinician verifies the clinical stability of the implants.
- The construction of the final prosthesis begins in the conventional way.



▲ Fig 10-13 Sequence and timing of steps for treatment option 1. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Checklist of materials required for treatment option 1

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Functional removable denture that will be converted
- Individualized impression tray
- Interocclusal relationship
- Stock of acrylic resin from the same lot used to make the prosthesis so that retouched areas will blend in acceptably

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Transgingival IOL abutments of the estimated length and their healing caps as well as additional abutments of varying lengths in case the pretreatment estimate of height has not been accurate (surgeon)
- Provisional titanium cylinders (laboratory)
- Try-in screws (laboratory)
- Gold screws (prosthodontist)
- Screwdriver to fix the provisional cylinders in place (prosthodontist and laboratory)
- Extensions, if needed (laboratory)
- Hexagonal screwdriver to attach the healing caps to the abutments (surgeon and prosthodontist)
- Impression copings for the IOL abutments for a pick-up impression (prosthodontist)
- IOL abutment polishing protectors for use during polishing (laboratory)
- Second set of artificial teeth for the converted prosthesis (laboratory)

Immediate-loading protocol

Presurgical and surgical phases

All prosthetic options for rehabilitating an edentulous mandible share similar presurgical and surgical phases. Options 1 and 2 differ in who attaches the prosthesis to the cylinders. In the first option, the laboratory does it and in the second the prosthodontist accomplishes the task.

The following case illustrates the prosthetic phase as it unfolds according to option 1.

Case history

The radiograph in Fig 10-14a shows the edentulous state of the mandible. It was decided that the molar could be retained but the canine should be extracted during implant surgery.

As a rule, posterior teeth whose prognoses are poor are left in place as long as possible until completion of the prosthetic stage and extracted afterward. These posterior teeth, which are scheduled for extraction, are temporarily left in place because they:

- Help to determine the vertical dimension of occlusion
- Facilitate the various steps of impression taking
- Serve as a landmark in the wax bite used to establish jaw relationships
- Assist the patient's sense of proprioception in control of the exerted masticatory forces

The removable denture this patient was wearing had to be remade because it was no longer functional. However, it was used to establish the vertical dimension and to determine the envelope of the mandibular arch. The occlusal surfaces were relined to obtain good vertical dimension (Fig 10-14b). A tooth was added in the canine area to aid in preparation of a duplicate prosthesis.

Two identical dentures were prepared so that a duplicate would be available if the denture used for the conversion prosthesis were broken during its transformation into a fixed prosthesis (Fig 10-14c). The supplementary cost of this additional denture is small in proportion to the overall fee for treatment, especially in view of its great benefit, if called into use, in permitting treatment to continue on schedule.

A surgical guide is molded from the new removable denture (Figs 10-14d and 10-14e). Designed not to be restrictive, it does not dictate the position and orientation of the implants. In this case, the section of the surgical guide that would cover the implants was opened (see Fig 10-14e). The portion covering the remaining molar was left in place and reinforced with pattern resin.

Six implants and the corresponding transgingival IOL abutments were placed (Fig 10-14f). Two of the implants were 4 mm in diameter and four were 5 mm in diameter. Because the 4-mm-diameter of the abutments was smaller than the neck of the 5-mm-diameter implants, an unintended platform-switching effect was obtained (Fig 10-14f). After sutures and healing caps had been placed, the prosthetic stage of treatment was initiated.

Provisional prosthetic phase

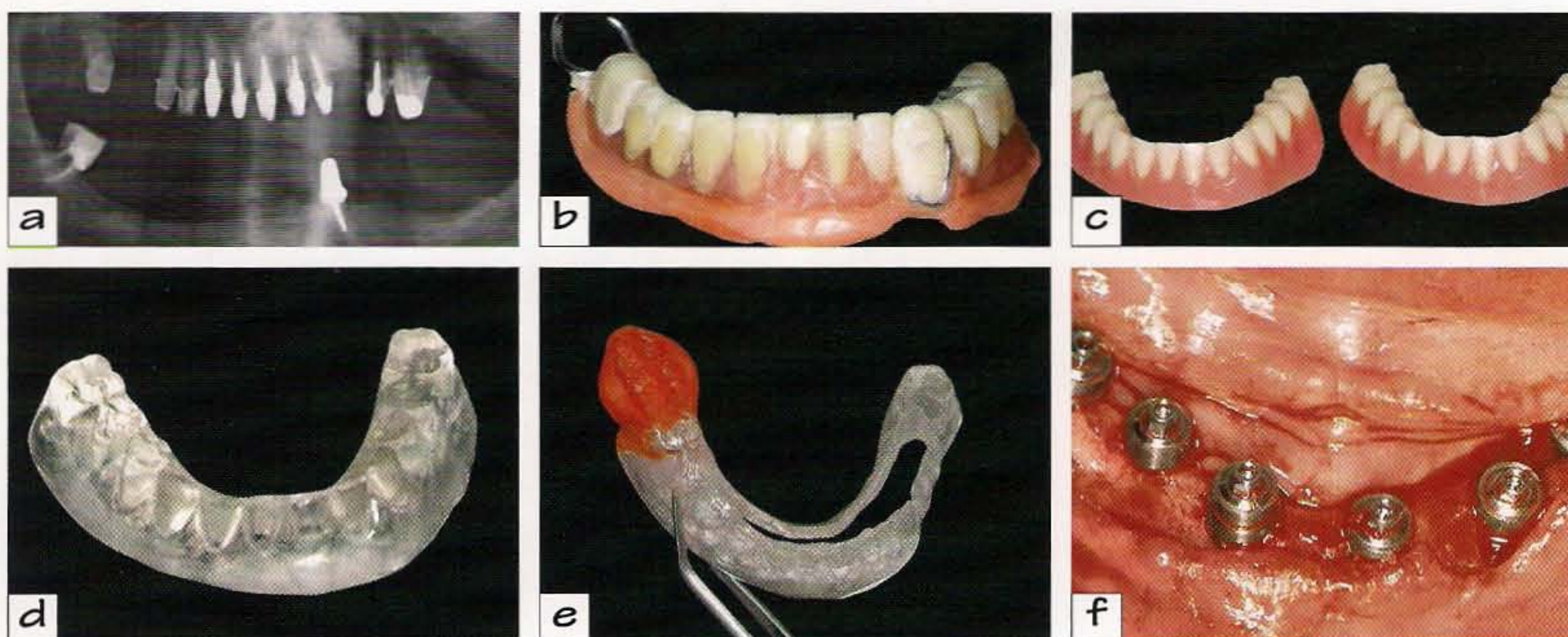
The patient arrived at the prosthetic phase with the healing caps attached to the transgingival abutments (Fig 10-15a).

Impression

Before the impression is taken, the healing caps are unscrewed. Then the impression copings corresponding to the IOL abutments are screwed in the transgingival abutments (Fig 10-15b). A control radiograph is made to ensure that the copings are properly seated, a step that is especially important for implants with external connectors (Fig 10-15c).

The impression tray is placed between the implants (Fig 10-15d). In this case, the central portion of the individualized impression tray was reinforced with a metal shaft embedded in the pattern resin. The openings in the impression tray are routinely closed with a sheet of wax or with surgical tape so that the impression material will not fuse occlusally (Fig 10-15e). A double-mix putty wash–light impression technique in polyether was used for this arch.

After the impression material sets, the transfer screws are localized and then unscrewed to free the impression (Fig 10-15e). The impression is removed and shows the position of the transgingival abutments. Next, the interocclusal relationship is recorded using the surgical guide; the remaining



▲ **Fig 10-14** Presurgical and surgical phases of treatment. (a) Pretreatment radiograph. Only two mandibular teeth remain, a canine and a molar. The canine will be removed and the molar left in place to serve as a posterior block and a guide for impression taking. (b) Pretreatment removable denture after modification. It was adjusted by the addition of an artificial tooth to replace the extracted canine and some acrylic resin to reestablish a correct occlusal plane. It can now serve as a basis for fabrication of the surgical guide and the prosthesis that will eventually be converted to the fixed prosthesis. (c) Double set of provisional prostheses. If the first prosthesis fractures or is compromised, the spare prosthesis can be utilized to allow treatment to continue on schedule. (d) Surgical guide in an early stage of fabrication. It was made from the patient's refurbished prosthesis. The positions of the implants remain to be determined. (e) Surgical guide. The guide is not restrictive but rather leaves a simple open space. The reinforcement of the occlusal surface over the remaining natural molar will facilitate registration of the interocclusal relationships. (f) Postoperative clinical situation. Six implants and their transgingival IOL abutments are in place. After suturing and positioning of the healing caps, the surgical phase will be completed. (Prosthesis by Dr S. Molloy.)

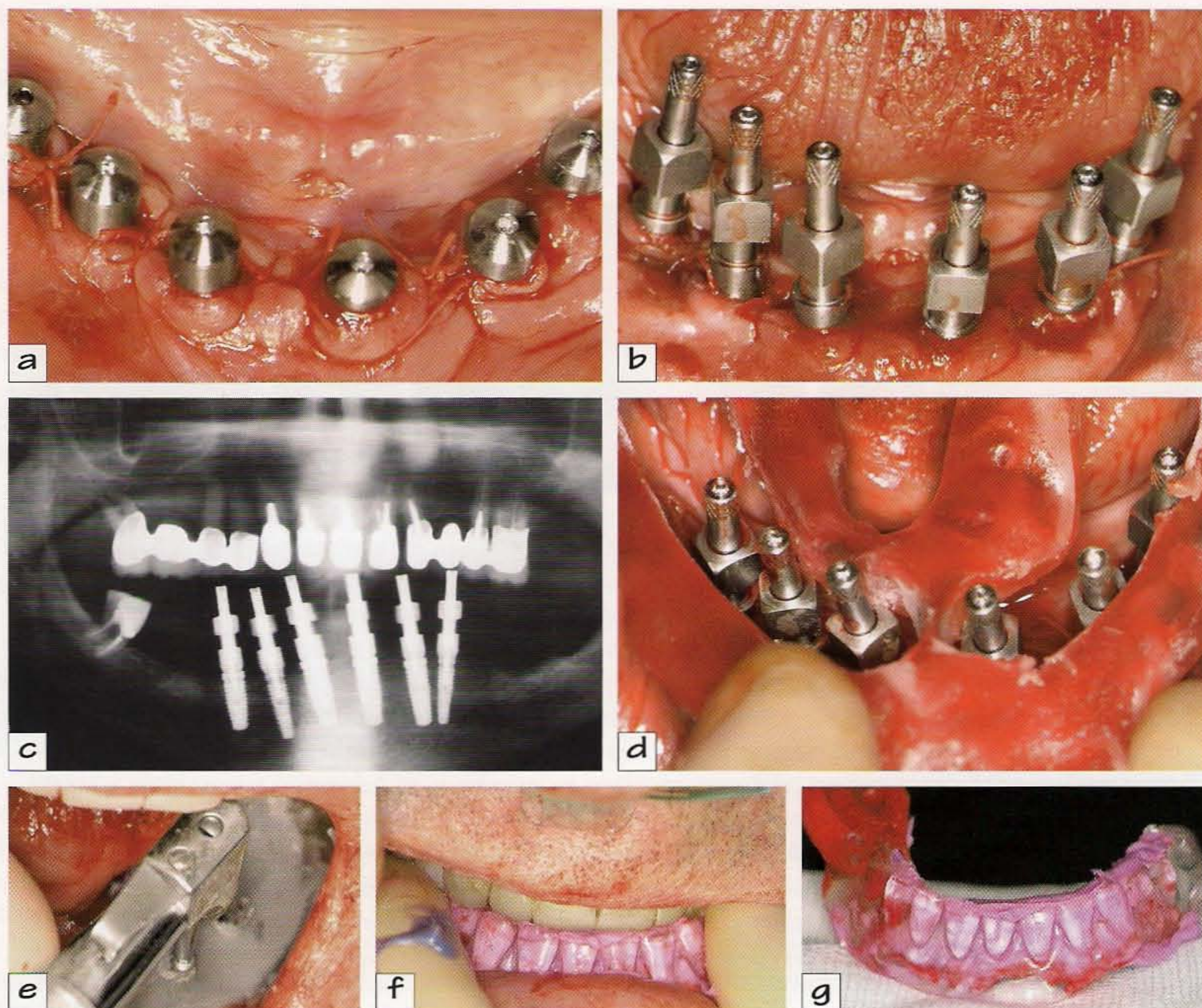
molar serves as a stop. The guide is filled with impression material and the patient closes the mouth in centric occlusion (Fig 10-15f). The impressions are sent to the laboratory (Fig 10-15g).

Measurement of anteroposterior distance

This information is necessary to determine how far the prosthesis can extend distally. The anteroposterior distance in this patient was 11.0 mm; therefore, the acceptable extension length was $1.5 \times 11.0 = 16.5$ mm. Consequently, the existing 8.0-mm-long extension did not have to be shortened and, in fact, a prosthetic extension going beyond the metal arm was possible (see Fig 10-17f).

Laboratory procedures

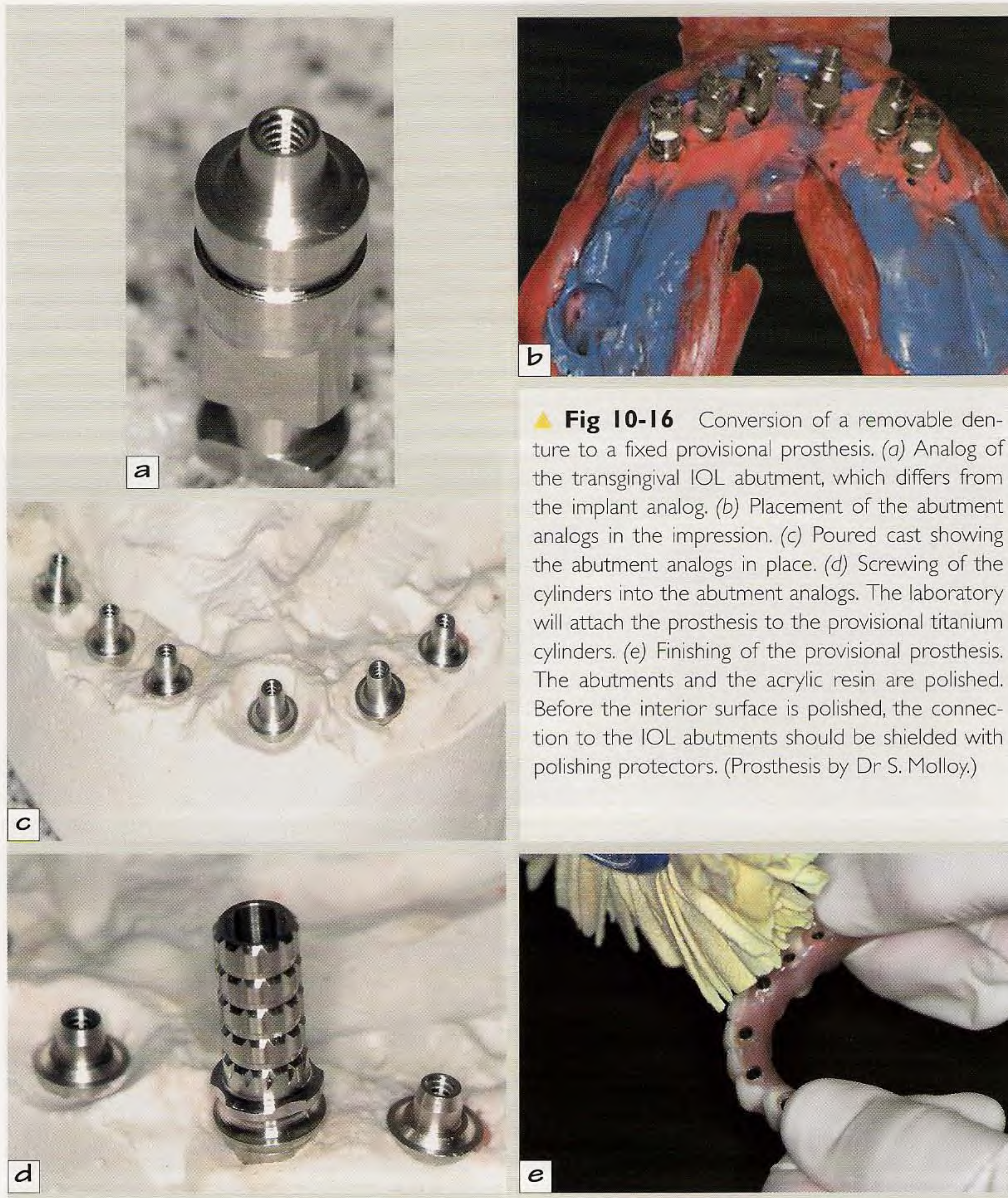
The analogs of the IOL abutments are placed in the impression while the plaster cast is poured (Figs 10-16a and 10-16b). After the cast has set, the cylinders are screwed in the abutment analogs (Figs 10-16c and 10-16d). Holes are prepared in the prosthesis so that the provisional cylinders can pass through it. The task of attaching the prosthesis with prepared holes to the cylinders is a straightforward procedure when performed in the laboratory; it is easily completed through the successive addition of resin layers.



▲ **Fig 10-15** Preparation of an impression for attachment of the provisional prosthesis to the abutments in the laboratory. (a) Clinical view at the beginning of the prosthetic phase of treatment. Note the presence of the healing abutments. (b) Attachment of impression copings to the transgingival abutments. (c) Radiograph showing the abutment copings in place. (d) Placement of the impression tray, which has been reinforced with acrylic pattern resin. (e) Unscrewing of the coping screws after the impression material has set. A wax sheet has been used to prevent the impression material from diffusing. (f) Recording of the interocclusal relationship. The patient has bitten into the surgical guide, whose anterior segment has been hollowed to receive impression material. (g) Registration of the interocclusal relationship. The molar that was left in place greatly facilitated this registration. (Prosthesis by Dr S. Molloy.)

The 10-mm cylinders are then ground down to the level of the prosthesis. When polishing is completed, the removable denture has been converted to a fixed prosthesis that can be immediately loaded (Fig 10-16e).

Figure 10-17 shows the new prosthesis that once had been a removable denture. All screw paths emerged lingually or occlusally on the crowns. Had the attachment step been performed in the patient's mouth, the right and left first premolars and the right canine would have been eliminated because of the large dimension of the holes. The long extensions on both sides of the conversion prosthesis corresponded to the allotted 1.5 times the anteroposterior distance. The embrasures were kept open to allow good hygiene. The provisional prosthesis had no metal reinforcement. (Variant procedures are described at the end of the discussion related to option 1.)



▲ **Fig 10-16** Conversion of a removable denture to a fixed provisional prosthesis. (a) Analog of the transgingival IOL abutment, which differs from the implant analog. (b) Placement of the abutment analogs in the impression. (c) Poured cast showing the abutment analogs in place. (d) Screwing of the cylinders into the abutment analogs. The laboratory will attach the prosthesis to the provisional titanium cylinders. (e) Finishing of the provisional prosthesis. The abutments and the acrylic resin are polished. Before the interior surface is polished, the connection to the IOL abutments should be shielded with polishing protectors. (Prosthesis by Dr S. Molloy.)

Delivery of prosthesis

The conversion prosthesis is ready to be delivered to the patient; in this case, this stage was reached within 72 hours after surgery. At this visit, the provisional prosthesis is screwed in at a 10 Ncm torque and the occlusion is adjusted. The screw holes are now filled. Figure 10-18a shows the provisional prosthesis for this patient secured to the abutments in the mouth. The abutments were high enough and the embrasures were satisfactorily clear.

Control radiograph

A panoramic radiograph is taken and will be used as a baseline to evaluate bone status over time (Fig 10-18b).



a

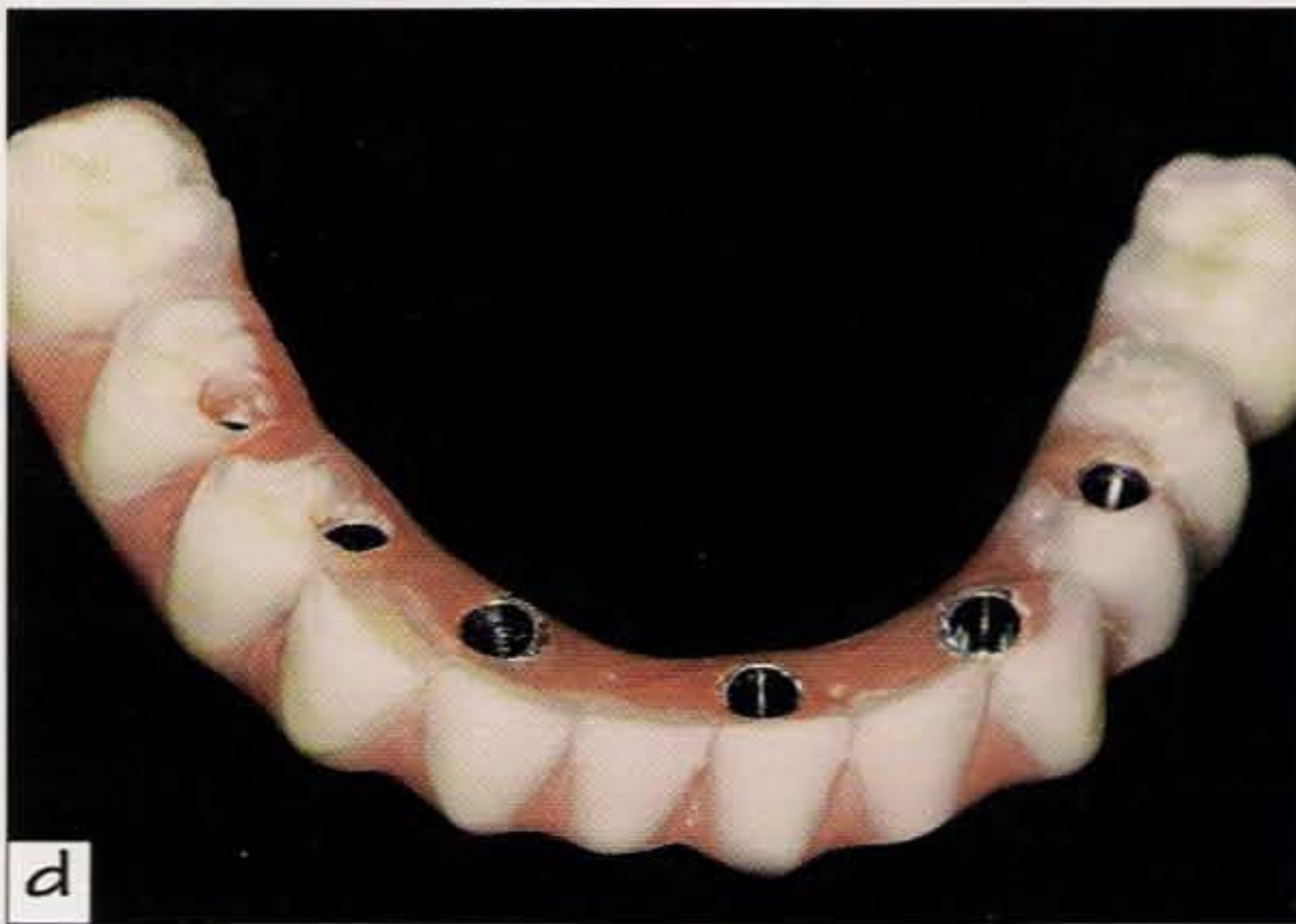
◀ **Fig 10-17** Comparison of the provisional fixed prosthesis with the original removable denture. (a) Original removable denture and fixed prosthesis, side by side. (b) Lingual view of the fixed prosthesis. (c) Lingual view of the original removable denture. (d) Buccal view of the fixed prosthesis. (e) Buccal view of the original removable denture (f) Interior surface of the fixed prosthesis. (g) Interior surface of the original removable denture. (Prosthesis by Dr S. Molloy.)



b



c



d



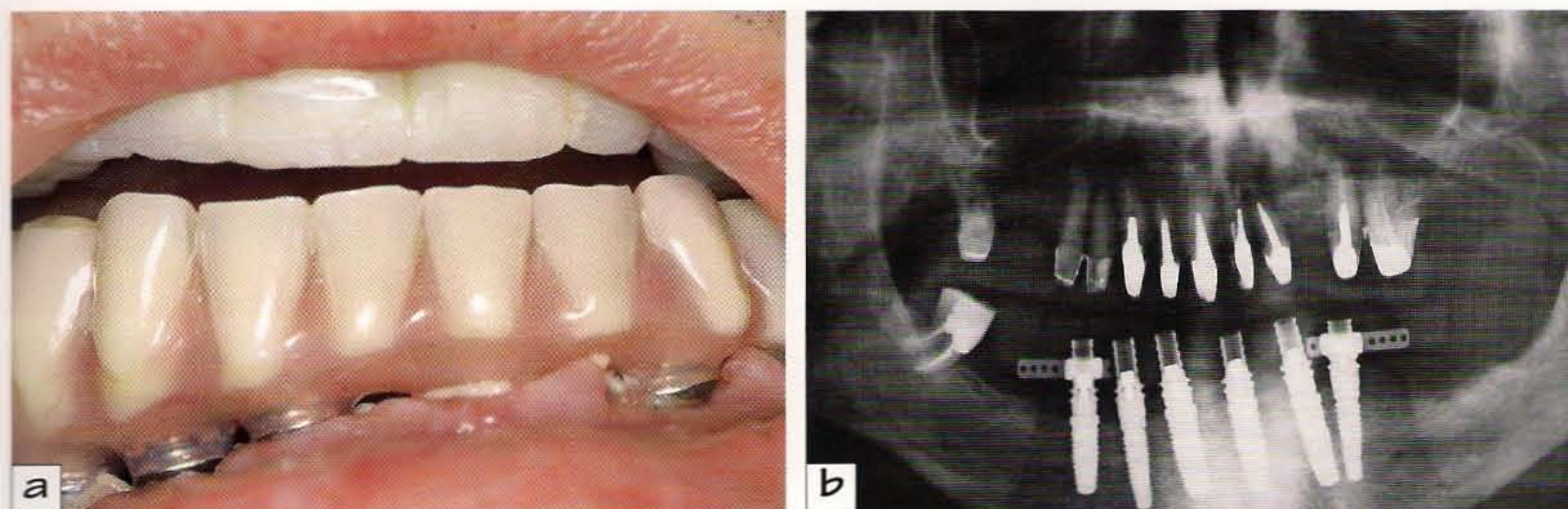
e



f



g



▲ **Fig 10-18** Provisional fixed prosthesis in the mouth, 3 days after surgery. (a) Buccal view showing the embrasures. Healing of the soft tissues is well advanced. (b) Control radiograph. Note the implants, the abutments, and the extensions on both sides. (Prosthesis by Dr S. Molloy.)



▲ **Fig 10-19** Postoperative follow-up and controls. (a) Buccal view at the 2-month examination. Note the stability of the gingiva around the transgingival abutments and in the area of the implant necks. (b) Buccal view at 3 months. The gingiva is still healthy, unchanged from the status at 2 months. (c) Enlarged view of the 3-month status with a small interproximal brush in place. The open embrasures make it easy for the patient to maintain good oral hygiene. (Prosthesis by Dr S. Molloy.)

Follow-up

Figure 10-19 shows the status of the gingiva during the period of osseointegration. Examinations revealed a healthy mucosa. The final prosthetic stage was started 3 months after osseointegration was confirmed.

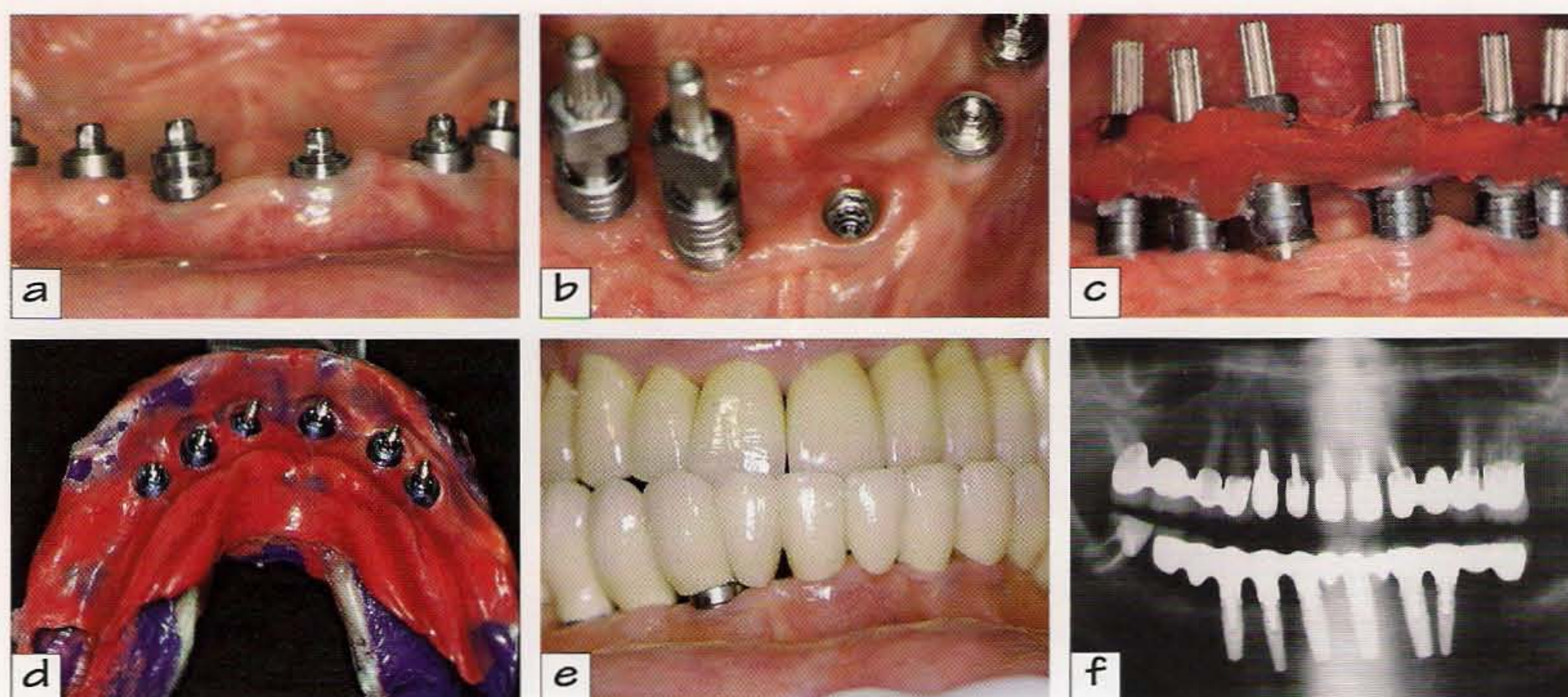
Final prosthesis

The final prosthetic phase began 6 months after surgery (Figs 10-20a and 10-20b). The final prosthesis was screwed directly in the implant necks, without the use of intermediary abutments.

The final impression is taken with impression copings screwed directly in the implant necks (see Fig 10-20b). The impression copings are joined together with a band of wax of fairly regular dimensions (Fig 10-20c), and the impression is taken in the usual way (Fig 10-20d). The impression is sent to the laboratory for the fabrication of a final prosthesis without transgingival abutments.

The laboratory fabricates a metal frame and attaches acrylic resin or ceramic teeth. At this time, the laboratory can add distal extensions if this was not already done for the provisional prosthesis.

When the final prosthesis is placed in the mouth, the occlusion is adjusted (Fig 10-20e). The radiograph shows the final prosthesis seated on the abutments (Fig 10-20f).



▲ **Fig 10-20** Final prosthetic phase. (a) Abutments at 6 months, after they were cleaned and the provisional prosthesis was removed. Note the presence of attached gingiva and the overall robust health of the mucosa. (b) Unscrewing of the IOL abutments and their replacement with implant impression copings. The gingiva is well healed in the region where the abutment has just been unscrewed. (c) Implant impression copings have been placed and reinforced with acrylic pattern resin. (d) Impression with the implant copings embedded in the impression material. (e) Final prosthesis in the mouth. (f) Radiograph of the final prosthesis. The prosthesis is seated directly on the implant necks. (Prosthesis by Dr S. Molloy.)

Treatment variants

The classic situation described most frequently in the literature is the treatment of an edentulous mandible by the placement of five or six implants in the anterior segment. However, the clinician may decide that some patients would benefit from changes in the number and placement of the implants or from the use of a metal framework for the provisional prosthesis. Two cases will be used to illustrate alternative treatment possibilities.

Variant 1: Patient treated with six implants placed in anterior and posterior healed and extraction sites

After all the mandibular teeth were extracted because of advanced periodontal disease (Fig 10-21a), seven implants were placed in both posterior and anterior extraction sites (Fig 10-21b). Six transgingival abutments were screwed in the implants and an impression was taken.

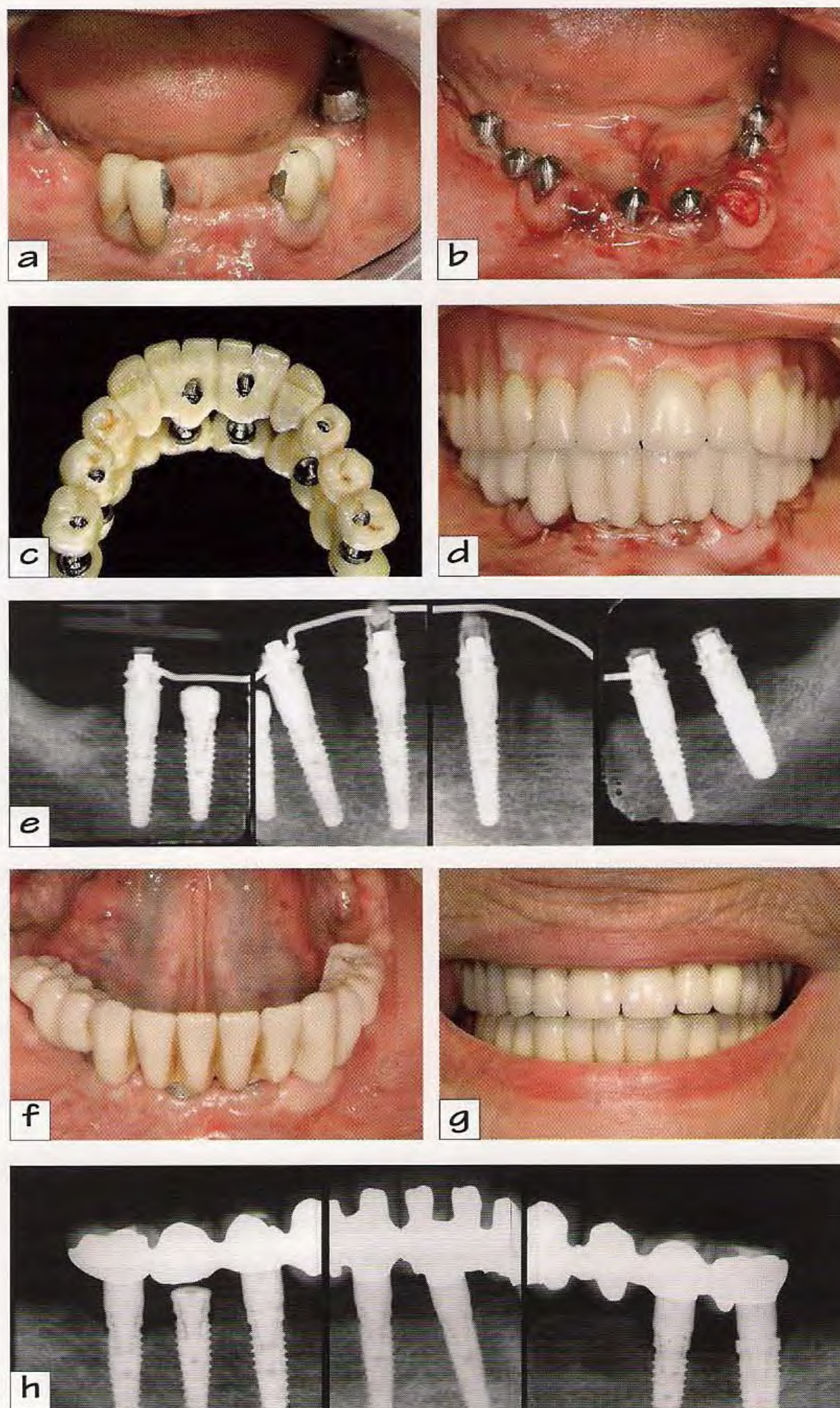
The impression was sent to the laboratory for the construction of a provisional prosthesis without an extension but with a metal reinforcement (Figs 10-21c to 10-21e). This metal support was indispensable because, distally, the prosthesis extended to the first molar regions.

The patient had asked, for esthetic reasons, that the embrasures not be made too conspicuous (Fig 10-21d). Although the patient had been instructed to clean the prosthesis carefully with a water jet and toothbrush, the 3-month recall examination revealed that oral hygiene had not been optimal (Figs 10-21f to 10-21h).

Variant 2: Patient treated with eight implants placed in anterior and posterior healed and extraction sites

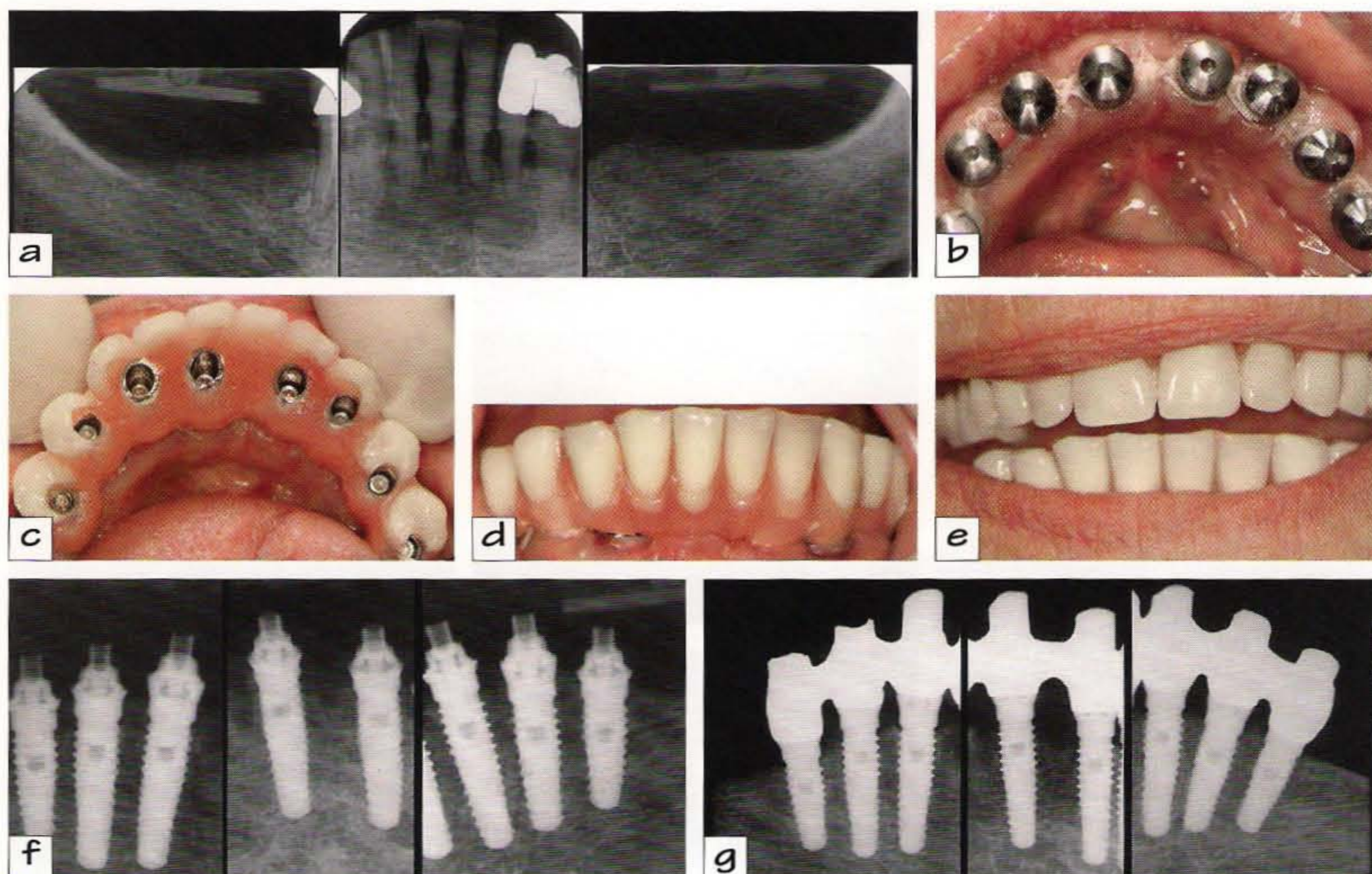
After multiple extractions of the remaining teeth (Fig 10-22a), six implants were placed in healed sites and two were placed in extraction sites (Fig 10-22b). Transgingival abutments with healing caps were placed on the implants, and an impression was taken.

► **Fig 10-21** Treatment variant in which six implants placed in the anterior and posterior segments were loaded immediately. (a) Preoperative view of the mandible. (b) Postoperative view of the mandible after removal of all remaining teeth and placement of seven implants in both extraction and healed sites. Healing caps have been seated on the transgingival abutments. (c) Provisional laboratory-fabricated prosthesis. Four implants were placed in posterior sites. (d) Provisional prosthesis, seated in the mouth. In accordance with the patient's wishes, the embrasures were not opened. (e) Radiographs of the provisional prosthesis. The abutments are seated on the implants and joined by a metal bar. (f) Clinical view after 3 months. Hygiene has been substandard, and cleaning was made difficult by the patient's wish to reduce the embrasure openings. (g) Final prosthesis in place. (h) Radiographs of the final prosthesis. The final prosthesis rests on the IOL abutments and not directly on the implant necks. Note that the middle implant on the right side is not in function because it is not needed; it was placed in case one of the other implants failed. (Prosthesis by Dr P. Rajzbaum.)



The impression was sent to the laboratory for construction of a provisional prosthesis with neither an extension nor metal reinforcement (Figs 10-22c to 10-22h). These were not required because of the generous number of implants supporting a prosthesis that was not excessively long.

The patient insisted that the embrasure openings be limited for esthetic reasons. In turn, she was urged to maintain a scrupulous oral hygiene regimen with toothbrush and water jet.



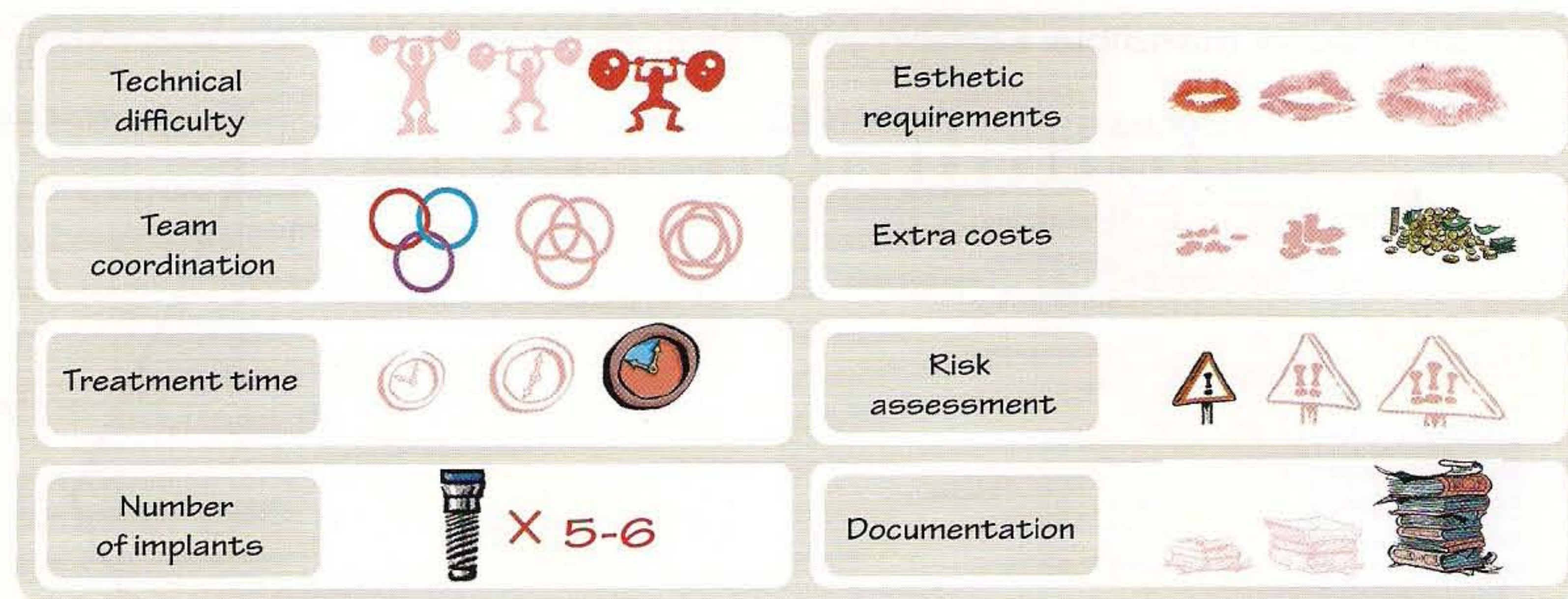
▲ **Fig 10-22** Treatment variant in which eight implants placed in the anterior and posterior segments were loaded immediately. (a) Preoperative radiographs. Bone loss accompanying advanced periodontal disease made extraction of the remaining mandibular teeth a necessity. (b) Eight implants and their transgingival abutments in position. (c) Laboratory-fabricated provisional prosthesis tried in the mouth before final polishing. The provisional cylinders, not yet polished, emerge lingually or occlusally in the access pathways for the screws. (d) Prosthesis in the mouth. The embrasures were only partially opened, in accordance with the patient's concept of good esthetics. (e) Patient's smile with the provisional prosthesis in place. (f) Radiographs of the provisional prosthesis. The abutments are in place on the implants without metal reinforcement. (g) Radiographs of the final prosthesis. The abutments of the provisional prosthesis have been removed for the final prosthesis. (Prosthesis by Dr A. Jakubowicz.)

Prosthetic phase: Treatment option 2

Fixed screw-retained provisional prosthesis placed immediately after surgery; the prosthesis is attached to the provisional cylinders at chairside (conversion of a removable denture to a fixed prosthesis).

Reminder:

- This option is selected when the principal determinant of treatment is the psychologic well-being of the patient who does not want to be deprived of teeth for even a short time. Accordingly, the clinician provides the patient with a provisional prosthesis immediately after surgery.
- The prosthodontist accomplishes this procedure immediately after surgery using the conversion prosthesis technique.



▲ **Fig 10-23** Key information for treatment option 2.

Key information for treatment option 2

Figure 10-23 summarizes the key aspects of prosthetic treatment in accordance with treatment option 2.

Technical difficulty is high

This is considered a difficult option because the prosthodontist attaches the prosthesis to the cylinders at chairside. During the surgical phase, the implants must be placed with good parallelism, and the access holes for the screws must be sufficiently lingual to the buccal surfaces of involved dental units. During the prosthetic phase, the placement of the cylinders in the prepared openings and their attachment to the prosthesis may be a long, demanding, and painstaking task. When that is accomplished, the occlusal adjustment may prove equally arduous.

Team coordination is limited

The prosthetic phase follows immediately after completion of surgery or is delayed briefly for a second session. The laboratory does not take part after the surgery.

Treatment time is extended

The combined consecutive surgical and prosthetic phases may endure for 4 to 6 hours, usually distributed into periods of 2 to 3 hours for surgery and 2 to 3 hours for the prosthetic session, during which the prosthodontist must laboriously join the provisional prosthesis to its implant supports.

Number of implants: 5 or 6

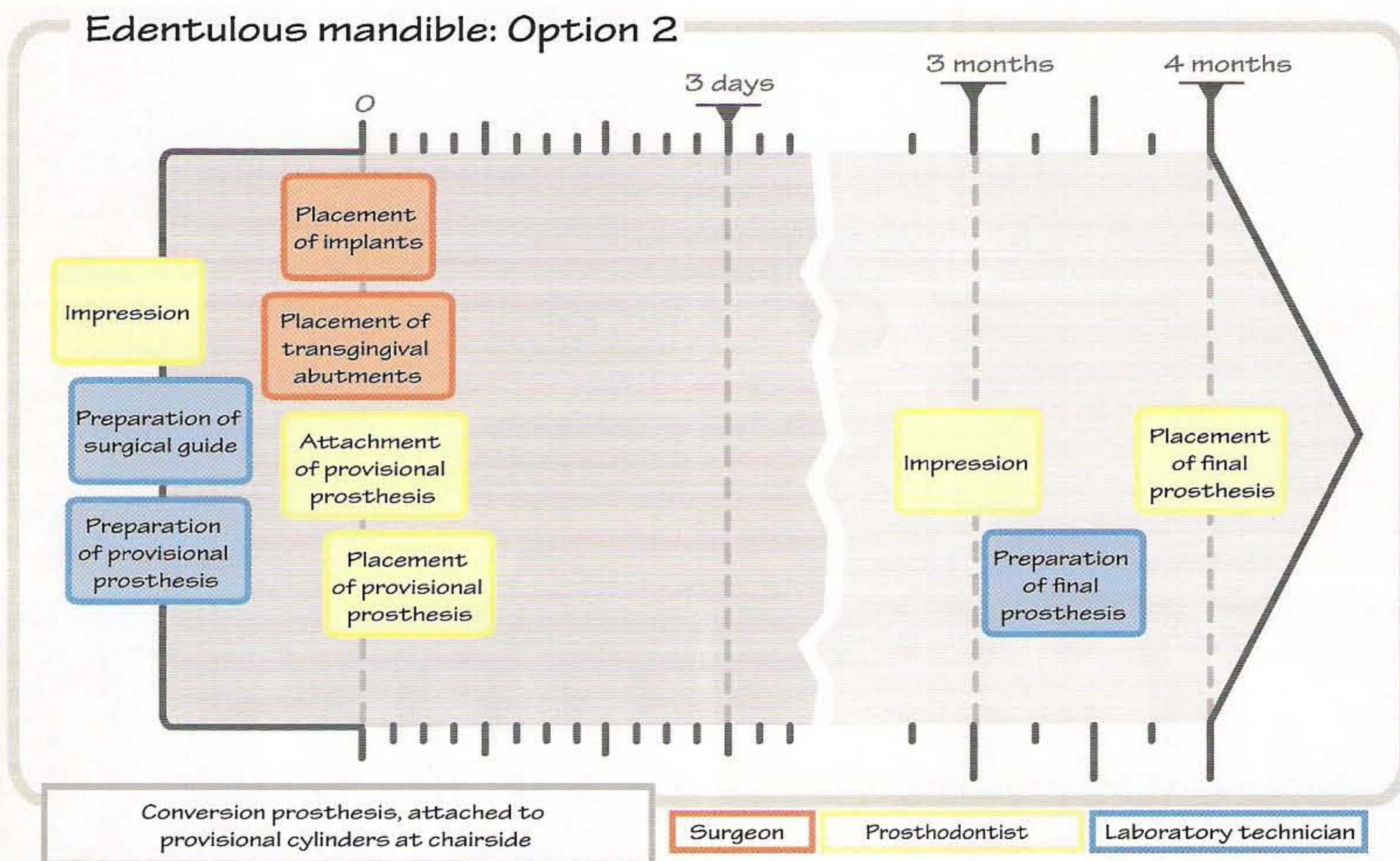
Five or six implants are usually used for this indication.

Esthetic requirements are low or nonexistent

Because there are no esthetic concerns in most cases of complete rehabilitation of an edentulous mandible, the strict rules for 3D implant placement do not apply.

Extra costs are substantial

The provisional prosthesis requires specific, expensive components that cannot be reused in the final prosthesis. Furthermore, the additional chair time increases the fee more compared with the laboratory-focused option 1.



▲ **Fig 10-24** Sequence and timing of steps for treatment option 2. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Additional risk is low

Obtaining primary stability, which is enhanced by the splinting effect of the immediately loaded prosthesis, should not pose any particular problem. Success rates are high and comparable with those of delayed-loading protocols.

Documentation in the literature is extensive

This indication for immediate loading is the one best documented in the literature. Immediate-loading procedures that involve posterior implants are not nearly as well documented.

Sequence and timing of steps for treatment option 2

Figure 10-24 illustrates treatment chronology for option 2:

- The laboratory completes construction of the surgical guide and the removable denture before implant placement.
- The implants are placed in the usual way.
- The prosthodontist begins the prosthetic phase immediately or shortly after surgery. The provisional prosthesis is seated within a few hours after placement of the implants.
- After a 2- to 4-month period to allow osseointegration to take place, the clinician verifies the clinical stability of the implants.
- The construction of the final prosthesis begins in the conventional way.

Checklist of materials required for treatment option 2

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Functional removable denture that will be converted
- Stock of resin from the same lot used to make the prosthesis so that retouched areas will blend in acceptably

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Transgingival IOL abutments of the estimated length and their healing caps as well as additional abutments of varying lengths in case the pretreatment estimate of height has not been accurate (surgeon)
- Healing caps (surgeon)
- Screwdrivers to attach the transgingival abutments (surgeon and prosthodontist)
- Titanium provisional cylinders (prosthodontist)
- Try-in screws for the provisional cylinders (prosthodontist)
- Gold screws for the provisional cylinders (prosthodontist)
- IOL extensions, if needed (prosthodontist)
- Hexagonal screwdriver to attach healing caps to the abutments (surgeon and prosthodontist)
- IOL abutment polishing protectors for use during polishing (prosthodontist)
- Sterilized rubber dam and rubber dam punch (prosthodontist)
- Second set of artificial teeth for the converted prosthesis (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

In option 2, the prosthodontist attaches the prosthesis to the cylinders. The following case illustrates the prosthetic phase as it unfolds in option 2.

Case history

A patient wearing complete maxillary and mandibular removable prostheses sought rehabilitation of her mandible with a fixed prosthesis (Fig 10-25). The patient, who was willing to endure a protracted session in the dental chair, requested immediate delivery of the prosthesis. Six 4-mm-diameter implants were placed with transgingival IOL abutments and their healing caps in the anterior segment of the mandible (see Fig 10-25d).

Provisional prosthetic phase

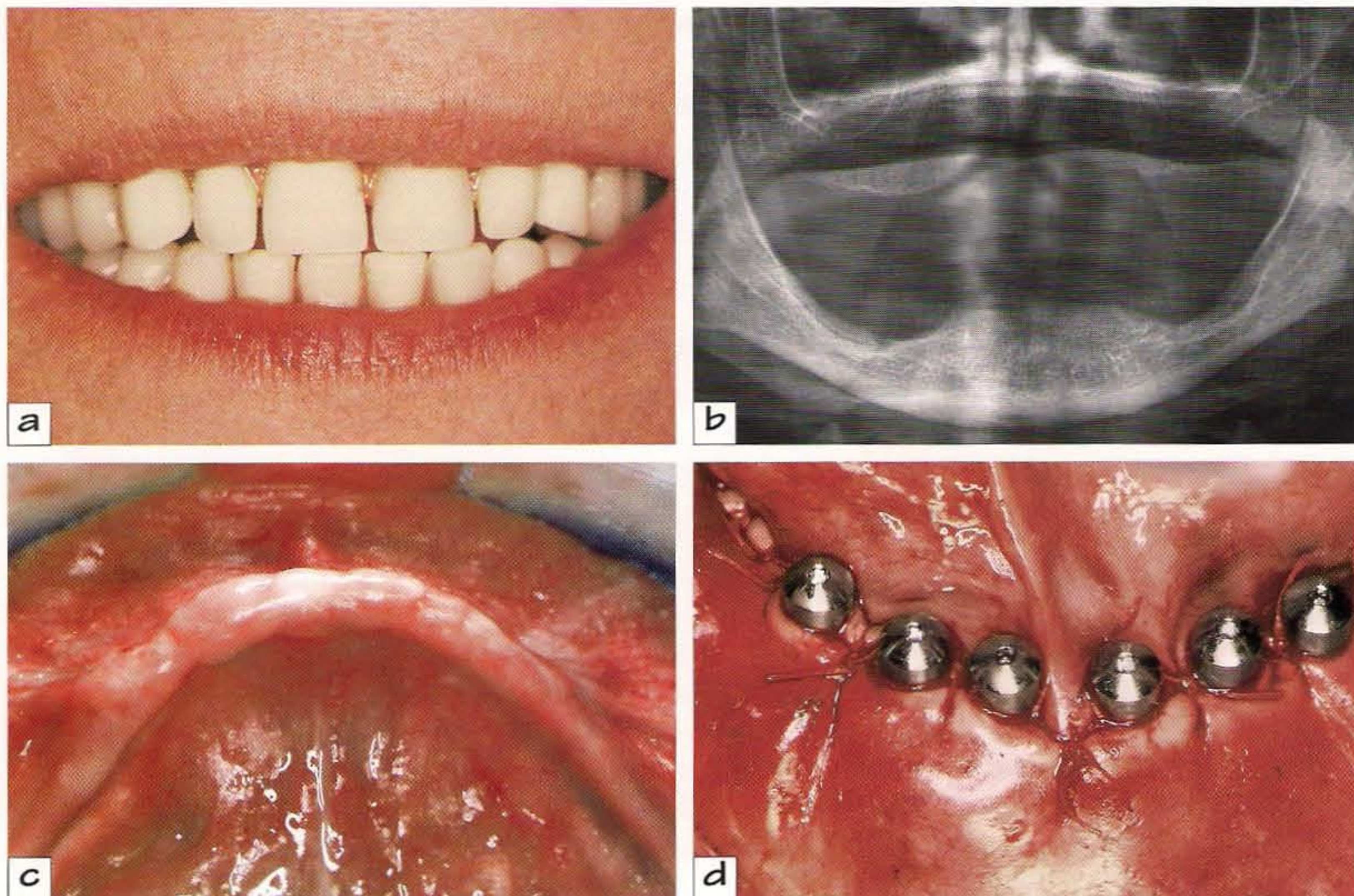
The patient arrived at the prosthetic treatment site with the healing caps fixed on the transgingival abutments (see Fig 10-25d).

Presurgical stage

Before the implants are placed, a new prosthesis is prepared and checked in the mouth (Figs 10-26a and 10-26b). A wax bite is taken to establish the interocclusal relationship (Fig 10-26c). It will be very useful in the later positioning of the hollowed prosthesis.

Measurement of anteroposterior distance

This procedure is the first step carried out at the prosthetic site. The measurement establishes the maximum allowable length of the distal extension of the prosthesis. In this case, the anteroposterior distance was 11.0 mm, and the acceptable length of the extension was $1.5 \times 11.0 = 16.5$ mm (Fig 10-26d). The planned 8-mm extensions did not have to be shortened. In accordance with the rules for anteroposterior distance, the prosthesis could be extended distally beyond the metal frame.



▲ **Fig 10-25** Presurgical and surgical phases. (a) Patient wearing a removable denture. (b) Radiograph showing the state of complete edentulousness. (c) Edentulous mandible before implant placement. (d) Implants placed in the anterior segment of the mandible. Healing caps have been placed on the transgingival abutments.

Placement of provisional cylinders

The clinician unscrews the healing abutments and tries the provisional cylinders and their extensions in the mouth to assess the parallelism of the implants and to determine the sizes of the holes that must be drilled in the prosthesis to allow correct seating on the cylinders (Figs 10-26e and 10-26f).

Placement of rubber dam

The clinician cuts a section of the cold-sterilized rubber dam in the shape of the anterior segment of the mandible and punches holes in the rubber dam through which the provisional cylinders can emerge. The dam is placed over the cylinders and is stabilized with the clamps specially made for this purpose (Fig 10-26g). Rubber dam separates the surgical field from the prosthetic, especially when self-polymerizing resins are to be used.

Hollowing of prosthesis to match cylinders and extensions

The clinician sets the prosthesis on the arch and verifies the occlusal landmarks. The prosthesis is removed, and holes for the provisional cylinders to pass through are created with a large pear-shaped acrylic resin bur. Usually, the openings will be more than 3 mm wide (Fig 10-26h).

Because the cylinders must pass readily through the openings in the prosthesis, even a slight inclination of their axes will force the clinician to widen the openings. This would weaken the prosthesis and increase its susceptibility to fracture.

After the cylinders have passed through the prosthesis, the extensions are bonded to the most distal cylinders with cyanoacrylate (Fig 10-26i). Then, the prosthetic base is hollowed to accept the extensions.

Connection of prosthesis to abutments

After the prosthesis is seated in the arch and its occlusion is adjusted, it can be attached to the implants through successive, small applications of acrylic resin (Fig 10-26j).

To bring the patient into correct occlusion, the prosthodontist sometimes may have to shorten the provisional cylinders. When an acceptable centric occlusion has been achieved, the clinician holds the prosthesis in place and asks the patient to open his or her mouth. Then, the most anterior cylinder is bonded at several points and the position of the prosthesis is noted. Next, the most distal cylinders are bonded, and finally the intermediate ones (Fig 10-26k).

After these drops of acrylic resin have polymerized, the prosthodontist unscrews the prosthesis and removes it, along with the rubber dam, from the patient's mouth. The gaps in the prosthesis around the cylinders still must be filled with acrylic resin.

The clinician first attaches the central cylinder to the prosthesis with successive applications of acrylic resin all around it. Polymerization is accelerated by placing the prosthesis in warm water for about 5 minutes. The other cylinders are then completely joined to the prosthesis in the same way in two successive stages.

After the cylinders are attached, each extension is covered with acrylic resin (Fig 10-26l). Because the resin is applied in successive stages, the risk of dimensional deformation (ie, polymerization shrinkage), which usually occurs with large applications of acrylic resin, is markedly decreased. With this procedure, the clinician succeeds in seating the prosthesis precisely on the abutments while reducing stresses on the cylinders.

Sometimes, a slight inclination of one or more implants causes the cylinders to diverge, making it difficult for the clinician to slide the prosthesis over them. To seat the prosthesis, the buccal surfaces of the teeth must be trimmed in a procedure that is tedious and time consuming, especially the first time the clinician confronts the problem. It is wiser, and much simpler, to remove the interfering teeth rather than to waste time in grinding them down bit by bit (Fig 10-26m). When a spare set of commercial prosthetic teeth is not available, the clinician may have to improvise and patch the existing acrylic resin teeth as well as possible (Fig 10-26n).

Adjustment of extensions and finishing of the interior and exterior surfaces of prosthesis

After the cylinders and the extensions have been secured to the prosthesis, the clinician reduces each cylinder to the level of the resin with a titanium bur. Both metal and acrylic resin are then finished and polished (Fig 10-26o). The distal extensions are sectioned at a point that will ensure that the prosthesis will conform to the predetermined anteroposterior distance (Figs 10-26o and 10-26p).

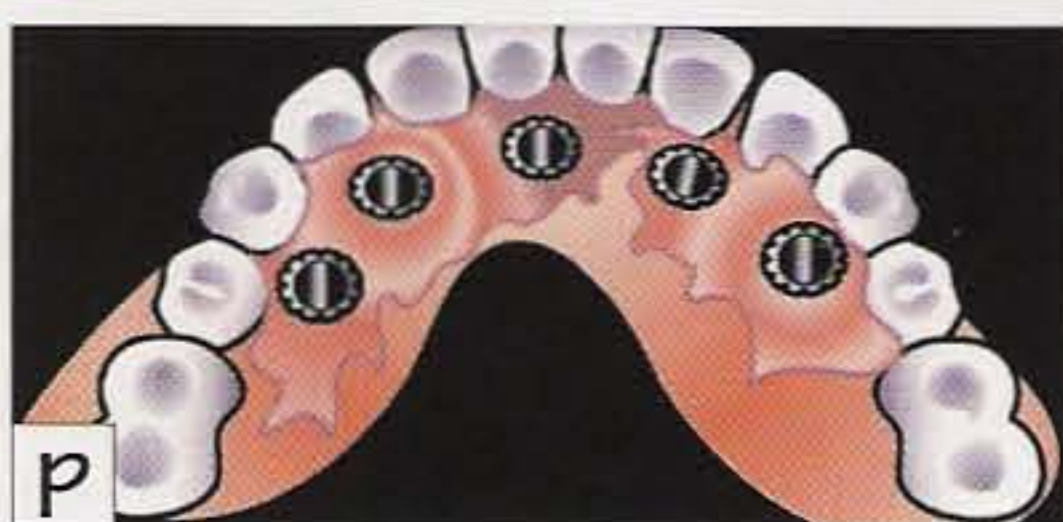
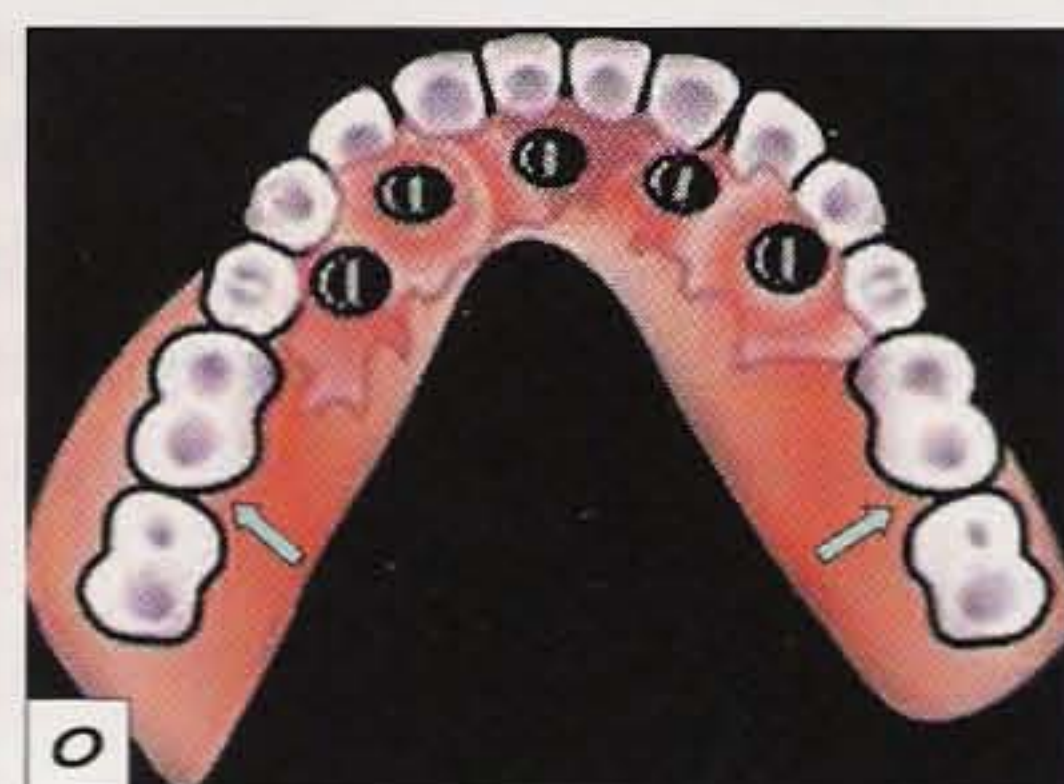
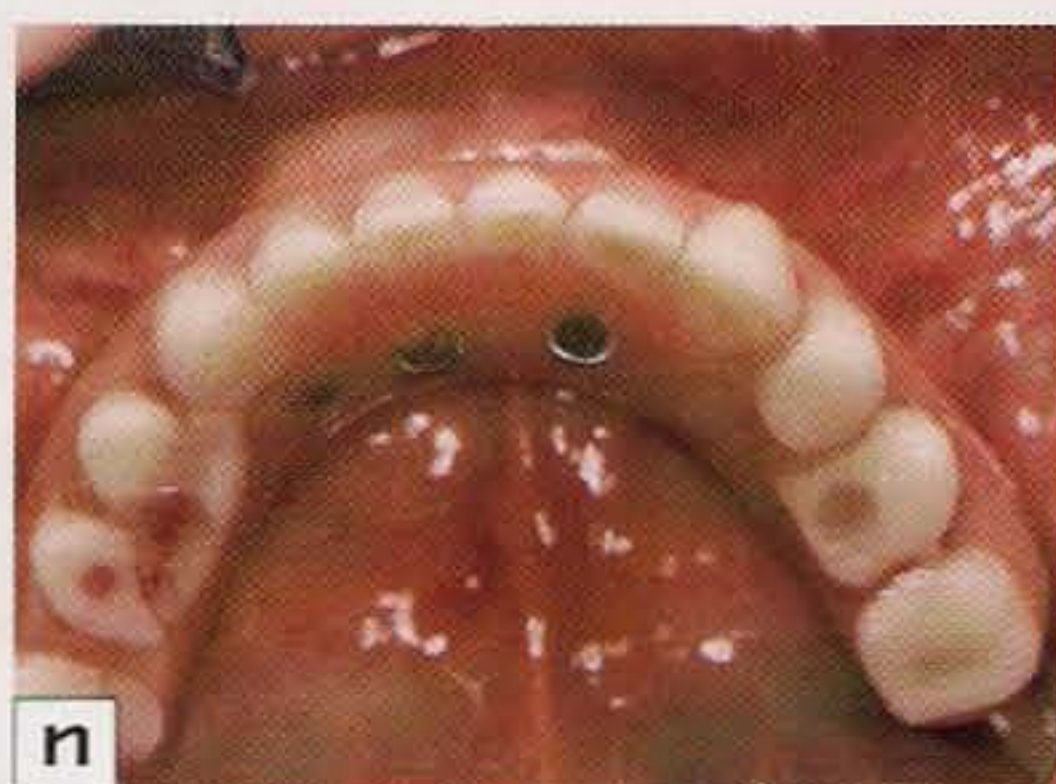
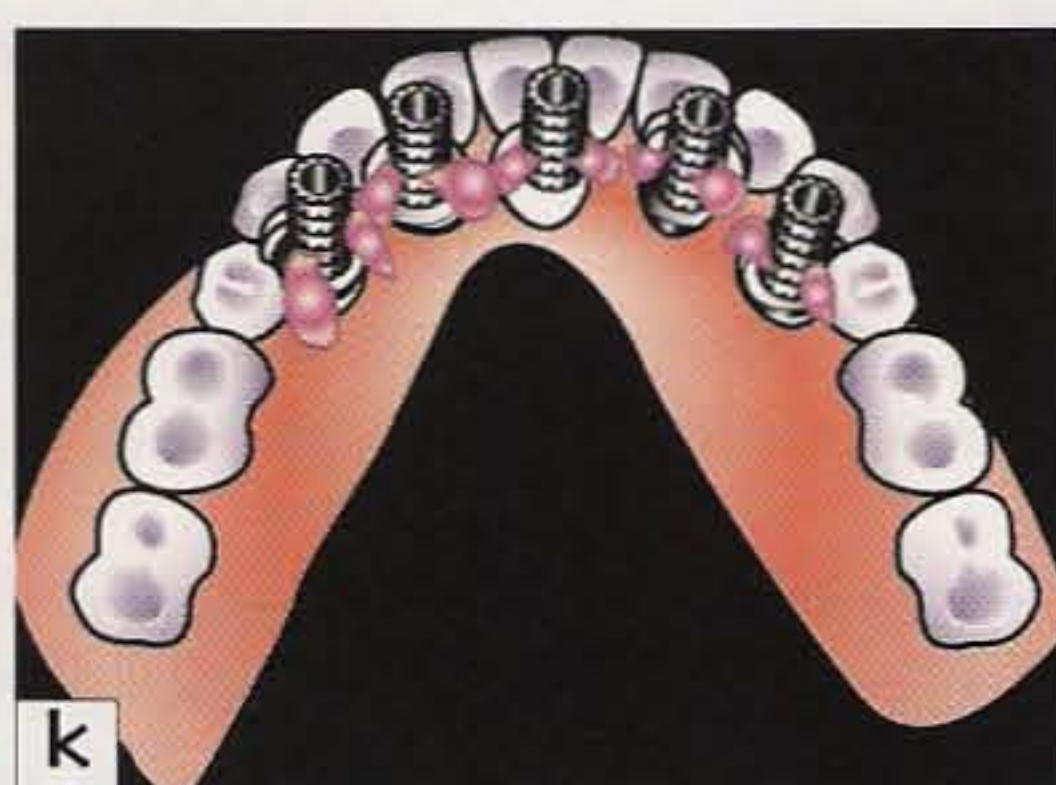
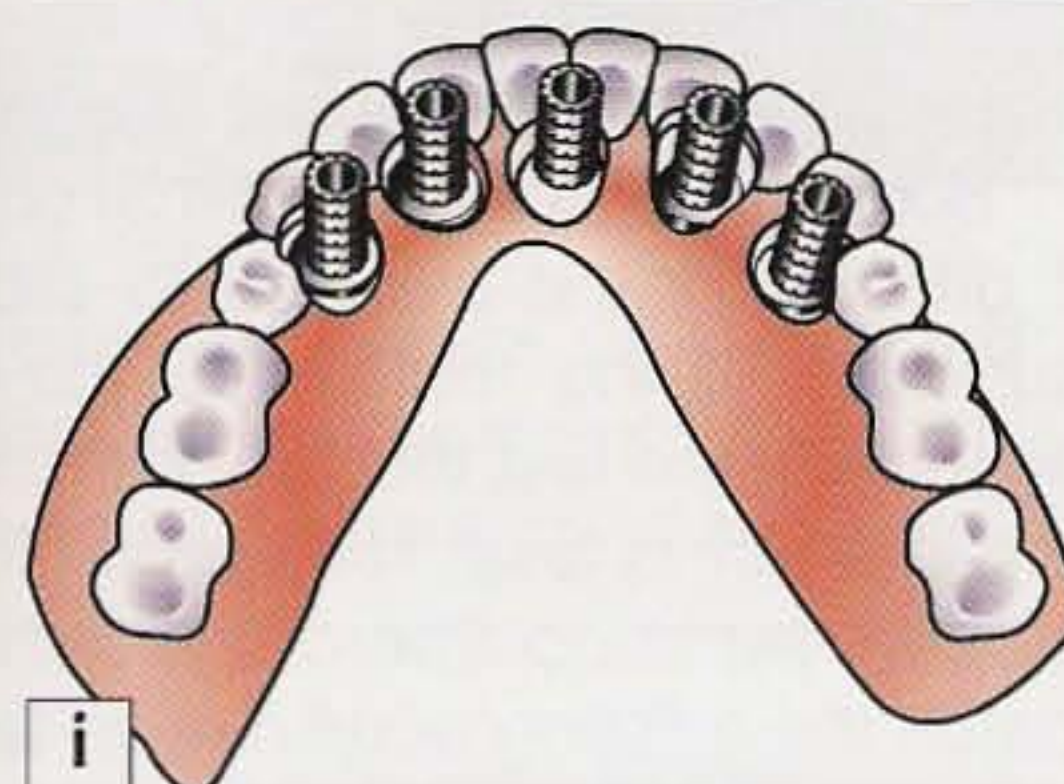
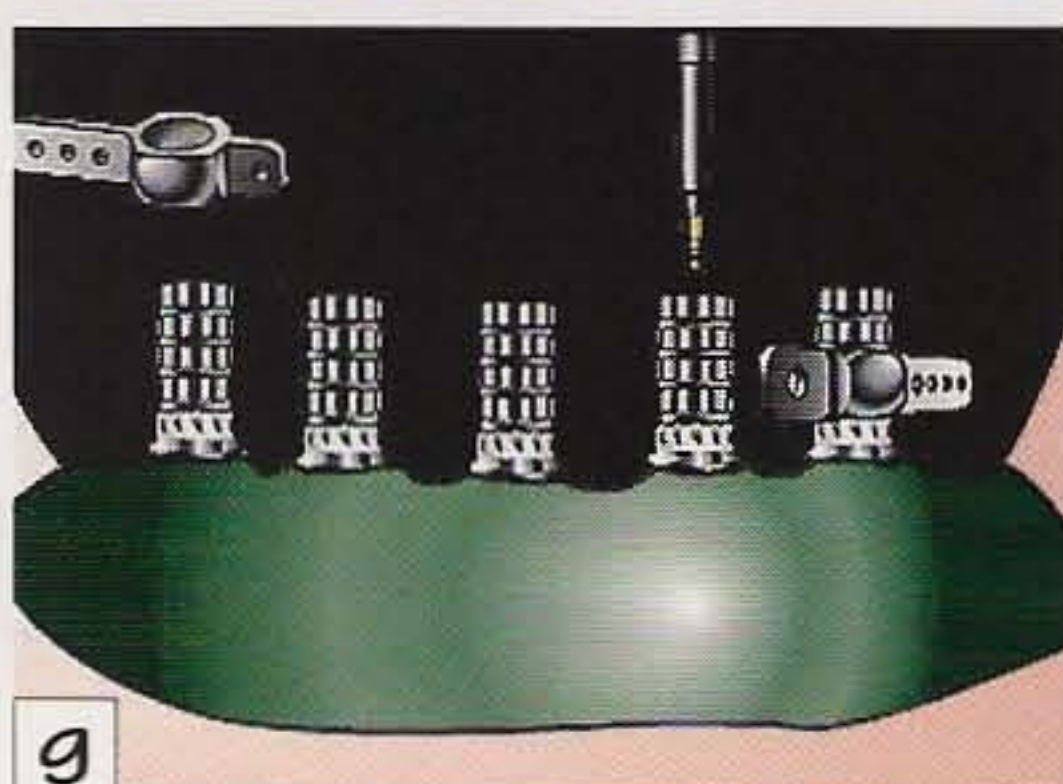
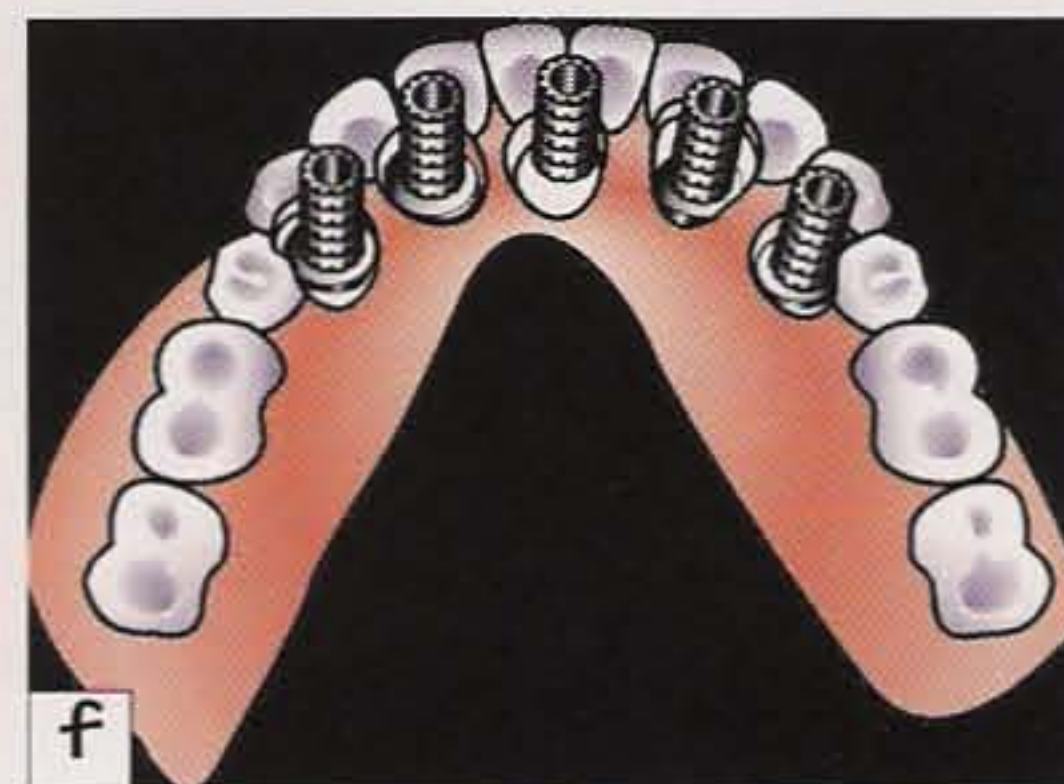
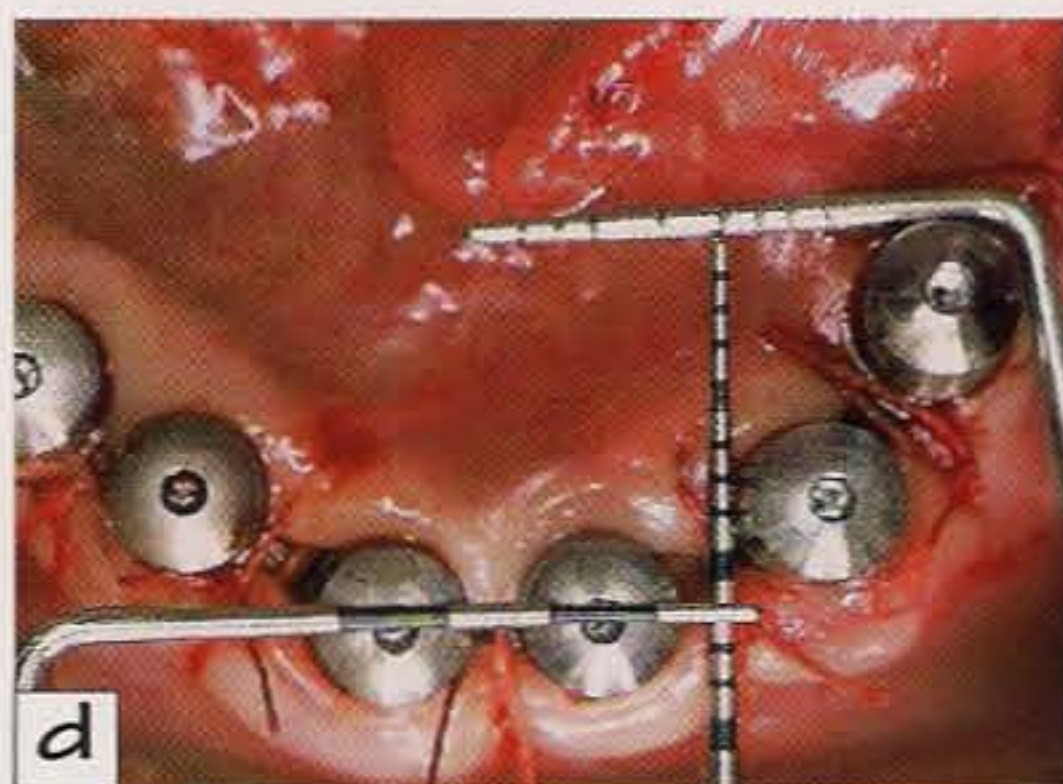
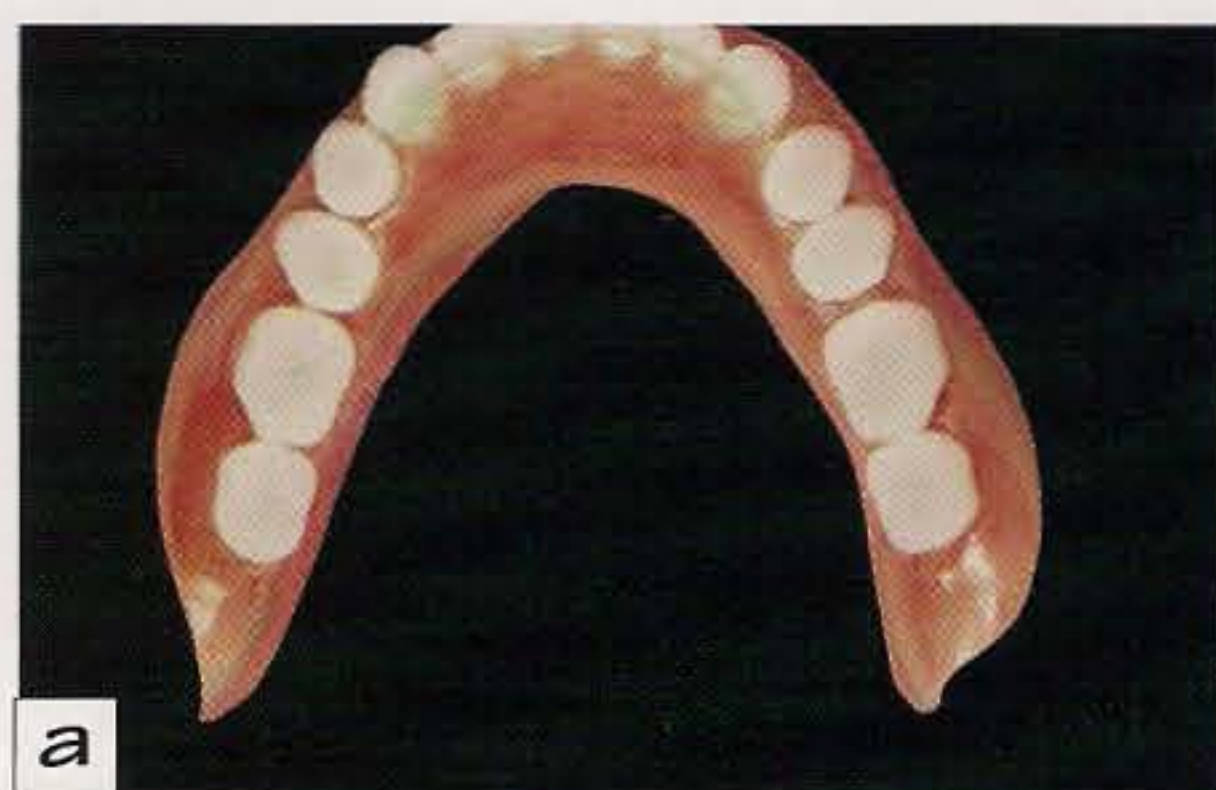
During the polishing of the interior surface, the base of each cylinder is protected with a blocking screw or polishing protector, specially designed for this purpose. Usually, the embrasures emerging from the interior surface buccally are made large enough to encourage good oral hygiene. In this case, the patient wanted the embrasures kept small so that the metal abutments would not be visible (Fig 10-26q); this represents an advantage for esthetics but a disadvantage for maintenance of good oral hygiene.

Placement of provisional prosthesis and adjusting occlusion

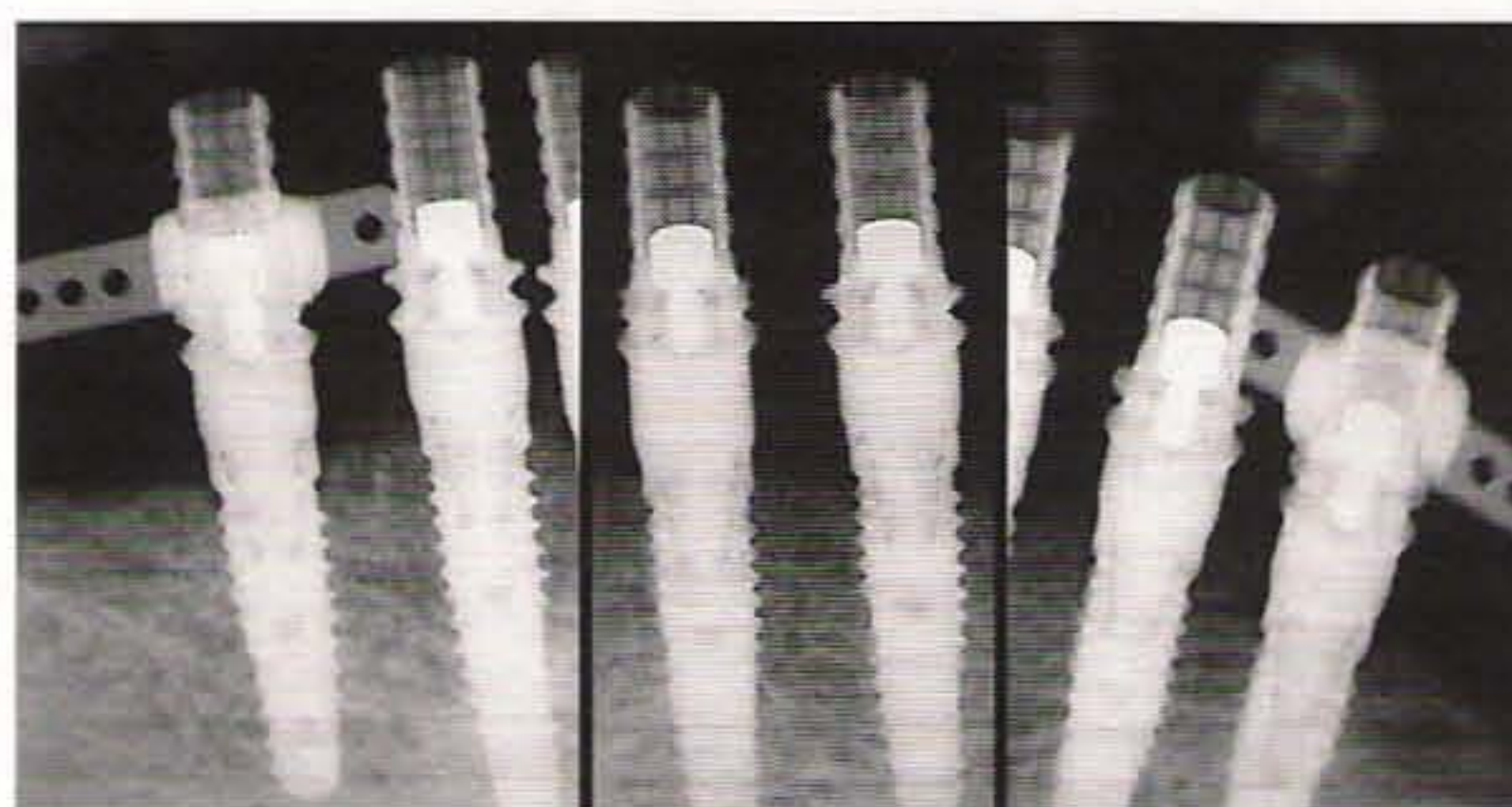
The finished provisional prosthesis is attached to the implants with the gold screws. The final step is balancing the occlusion. Articulating paper is used to identify high spots, which are ground away until an equilibrated occlusion is established.

Control radiograph

At the close of the treatment, a radiograph is taken to ensure that the implants have been positioned correctly and that the cylinders and extensions are well seated (Fig 10-26r). This radiograph will be used as a baseline to evaluate bone status over time and observe possible development of any abnormalities.



◀ **Fig 10-26** Prosthetic phase. (a) Preparation of a new removable denture that will be converted to a fixed prosthesis. (b) Try-in of the new denture in the mouth before implant placement. (c) Registration of the interocclusal relationship before implant placement. (d) Measurement of the anteroposterior distance. It was 11 mm in this case, allowing installation of 16-mm distal extensions on both sides. (e) Try-in of the abutments and their extensions in the mouth. This allows the clinician to evaluate the divergence in the angulations of the cylinders. (f) Estimation of the openings that will have to be cut for passage of the cylinders. This schematic shows an ideal situation where the cylinders diverge only slightly. (g) Rubber dam in place with the cylinders and their extensions passing through it. They will be attached later with gold screws. (h) Openings prepared for the implants. If the cylinders are slightly divergent, openings of this type would not allow proper seating of the prosthesis on the cylinders (see Fig 10-26m). (i) The prosthesis is tried on the cylinders. (j) Verification of the position of the prosthesis in occlusion. Sometimes the cylinders must be shortened to permit correct occlusion. (k) Attachment of the prosthesis to the cylinders with a few drops of acrylic resin. The gaps around the cylinders will be completely filled, out of the mouth, through progressive addition of acrylic resin. (l) Embedding of the extensions in resin, also accomplished through progressive additions. The extension on the right is already covered; the one on the left will be next. (m) Slightly divergent cylinders. To allow seating of the prosthesis, the left second premolar had to be removed and the occlusal surface of the right first premolar had to be ground down considerably. (n) Prosthesis, for which a spare set of teeth had not been prepared. The prosthodontist repaired the adjusted teeth with the available material. (o) External surface of the prosthesis after finishing and polishing. Arrows indicate the points to which the distal extensions must be cut. (p) Final size of the prosthesis after removal of the excess distal material. (q) Prosthesis in the mouth. The patient had requested that the embrasures be kept small for esthetic reasons. Because the small embrasures would interfere with good hygiene, the patient was reexamined frequently and was urged to maintain the highest possible level of home care throughout the provisional phase. (r) Radiograph taken after placement of the prosthesis, showing the implants, the titanium transgingival abutments, the gold screws, which are the most radiopaque, and the extensions.



▶ **Fig 10-27** Six-month follow-up radiographs. The bone level has stabilized above the first thread.

Follow-up

In this case, the provisionalization period lasted 6 months. The radiograph taken at 6 months revealed that the bone had stabilized at a satisfactory level, which, for most implants, was just above the first thread (Fig 10-27).

Prosthetic phase: Treatment option 3

Fixed screw-retained final prosthesis; the prosthesis is fabricated in the laboratory and placed within 72 hours after surgery.

Reminder:

- This option is selected when the principal determinant of treatment is cost, which should be kept as low as possible, or the duration of the overall treatment time, which should be as short as possible.
- This approach can be used only when micromovements have been successfully minimized (see chapter 4) and all the implants exhibit especially good primary stability (insertion torque of greater than or equal to 45 Ncm).
- When dealing with extraction sites, clinicians should embark on this option with greater caution.

Key information for treatment option 3

Figure 10-28 summarizes the key aspects of prosthetic treatment in accordance with treatment option 3.

Technical difficulty is high

Compared with the previously discussed options, the level of difficulty is high with this approach. During the surgical phase, the implants must be placed with good parallelism, and the screw access holes must be sufficiently lingual to the buccal surfaces of the involved dental units.

Although the laboratory fabricates the final prosthesis, the prosthodontist still must adjust the occlusion chairside in a procedure that is more demanding and more complex than it is for a provisional prosthesis, because the occlusal patterns prepared at this time will have to last indefinitely, not temporarily.

Team coordination is tight

Although the surgical and prosthetic phases are not accomplished in the same session, the prosthetic phase does begin immediately after surgery with the taking of an impression that is dispatched promptly to the laboratory. Cooperation between prosthodontist and laboratory must be tight for the final prosthesis with a metal frame to be delivered successfully within the 72-hour limit.

Treatment time is average

The surgical and prosthetic phases are not accomplished in the same session. The time needed for surgery is the same as in other protocols, but the prosthetic phase includes a final adjustment of occlusion for the definitive prosthesis. Total treatment time is 2 to 3 hours for the surgical phase and 1 to 2 hours for the prosthetic phase. The latter is accomplished in two stages, the first for preparation of the impression after surgery and the second for delivery of the prosthesis and adjustment of the occlusion.

Number of implants: 5 to 8

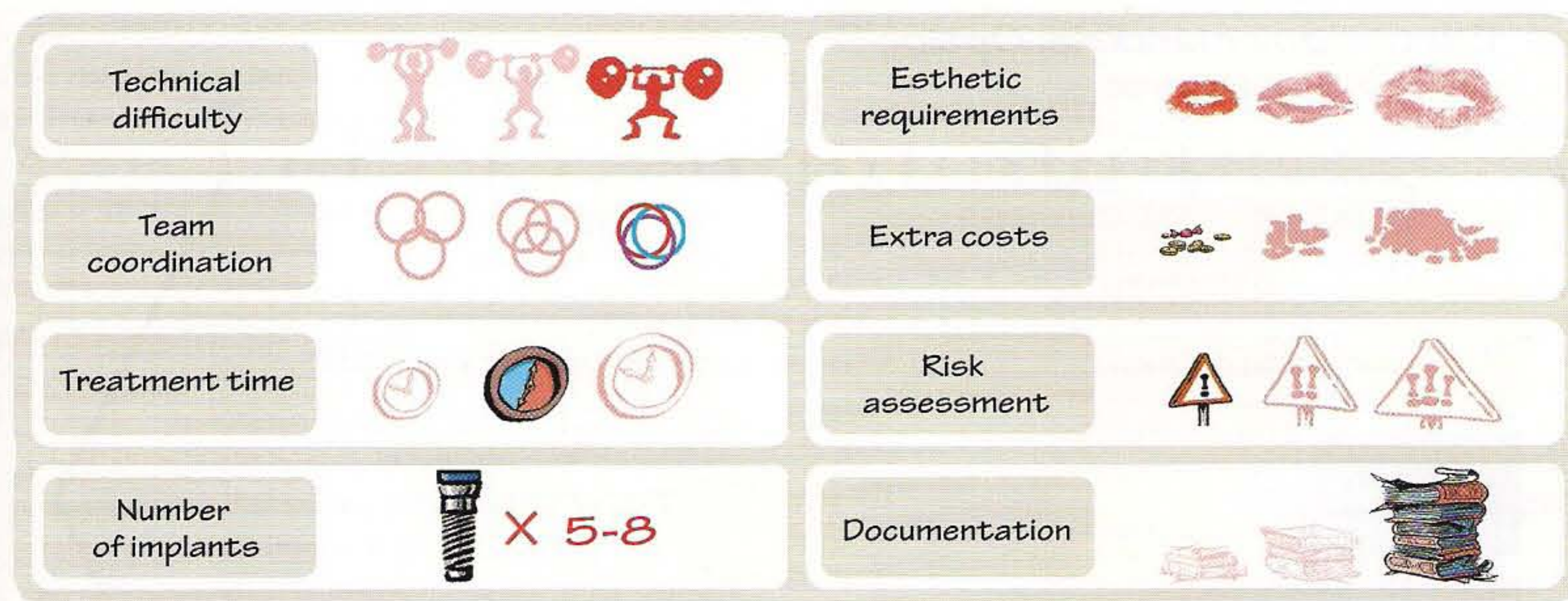
More implants can be used for this protocol than for the others, especially when the posterior segment of the mandible is involved.

Esthetic requirements are low or nonexistent

Because there are no esthetic concerns in most cases of complete rehabilitation of an edentulous mandible, the strict rules of 3D implant positioning do not apply.

Extra costs are low

Costs are reduced substantially by the elimination of the provisional prosthesis. However, should the final prosthesis prove unsatisfactory and have to be replaced, the costs will be greatly



▲ **Fig 10-28** Key information for treatment option 3.

increased. In accordance with the principle of informed consent, patients should be made aware of this possibility from the start.

Additional risk is low

Obtaining primary stability, which is enhanced by the splinting effect of the immediately loaded prosthesis, should not pose any particular problem. Success rates are high and comparable to those of delayed-loading protocols.

Documentation in the literature is extensive

This indication for immediate loading is the best documented in the literature, but the options of immediate placement of final prostheses and incorporation of posterior implants are not nearly as well documented.

Sequence and timing of steps for treatment option 3

Figure 10-29 illustrates the treatment chronology for option 3:

- The laboratory participates in treatment before and after implant placement. Before surgery, the laboratory constructs the surgical guide and the individualized impression tray. After surgery, the laboratory fabricates the final prosthesis when it receives the impression.
- The implants are placed in the usual way.
- The prosthodontist takes an impression immediately after implant placement.
- The impression is sent to the laboratory for construction of a final prosthesis that is delivered no later than 72 hours after surgery.

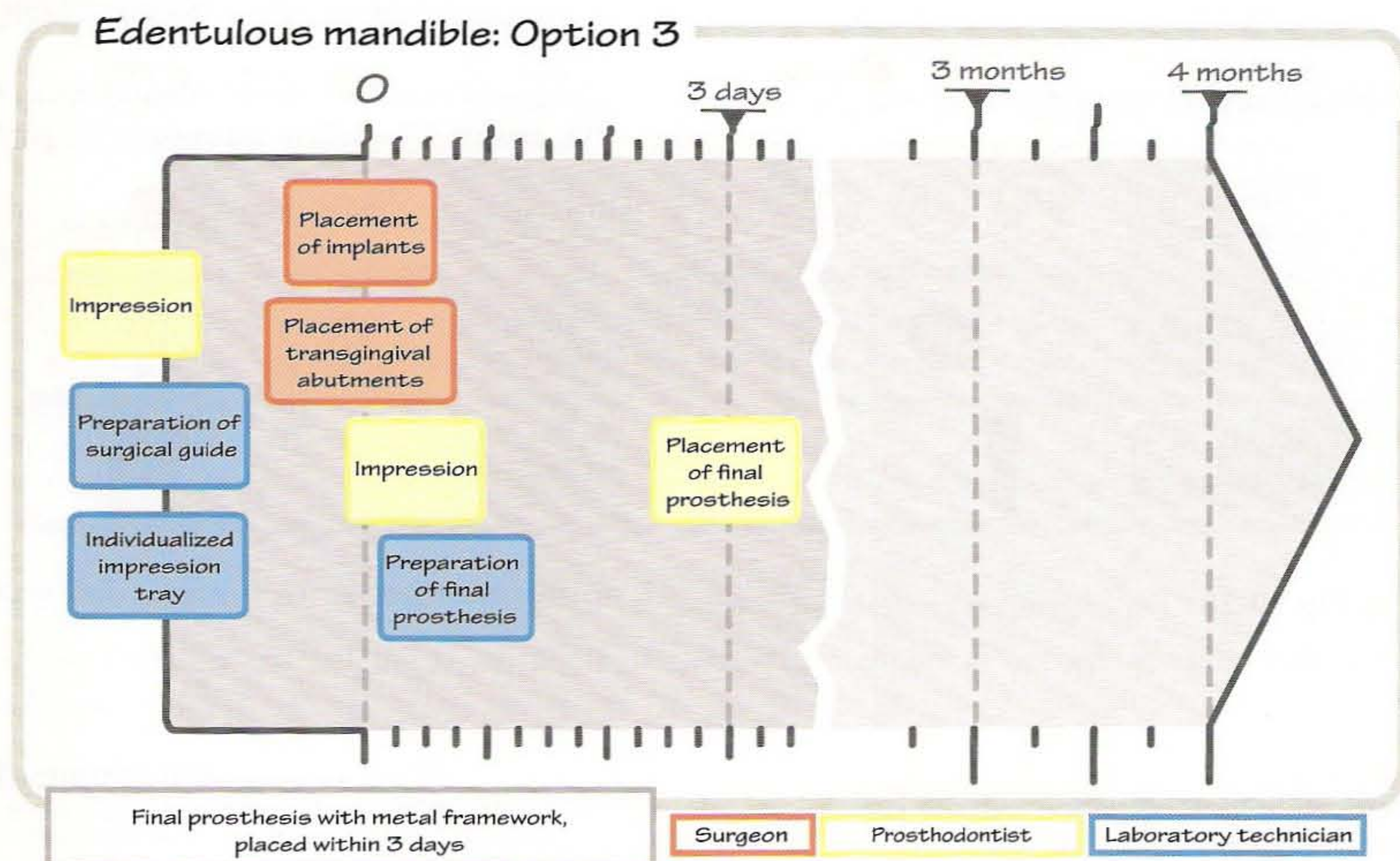
Checklist of materials required for treatment option 3

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Individualized impression tray

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)



▲ **Fig 10-29** Sequence and timing of steps for treatment option 3. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

- Abutments (surgeon):
 - Transgingival IOL abutments of the estimated length and their healing caps as well as additional abutments of varying lengths in case the pretreatment estimate of height has not been accurate or
 - Healing abutments if the prosthodontist wants to take the impression directly on the implant neck without intermediate transgingival abutments
- Try-in screws (laboratory)
- Gold screws (prosthodontist)
- Hexagonal or square screwdrivers for the abutment screws (surgeon, prosthodontist)
- Impression copings (prosthodontist):
 - For the IOL abutments or
 - For the implants (corresponding to the number of implants)
- Analogs (laboratory):
 - To match the IOL abutments or
 - To match the implants
- UCLA abutments with gold bases (laboratory)

Immediate-loading protocol

Presurgical and surgical phases

All prosthetic options for rehabilitating an edentulous mandible share similar presurgical and surgical phases. Option 3 differs from the others because the laboratory fabricates a final prosthesis with a metal frame, rather than a provisional prosthesis.

Case history

This case illustrates the prosthetic phase as it unfolds in option 3. The surgical phase of treatment for the mandible that will be edentulous after extraction of the remaining teeth has been already described.

Eight implants were placed in extraction sites, a higher number than usual because the ultimate goal was delivery of an immediately loaded final prosthesis to the patient. For this procedure, reliability is the foremost concern, so it is important to reduce the risk of implant failure as much as possible.

Final prosthetic phase

The final prosthesis can be supported by one of two options:

1. Transgingival IOL abutments. This option is selected when the implants are deeply subcrestal or when there has been a marked loss of vertical dimension. In both cases, the transgingival abutments elevate the prosthetic plane in a coronal direction.
2. Directly on the implant neck. This option is selected for most cases because it reduces both the number of construction levels in the prosthesis as well as the overall cost of the prosthetic components.

The protocol for fabrication of an impression for this option is the same as it is for option 1, where the laboratory affixes the prosthesis. At the beginning of the prosthetic phase, the impression copings are screwed in the abutments (Figs 10-30a and 10-30b). Next, the clinician tries in the individualized impression tray and adjusts it if necessary (Fig 10-30c). The clinician places impression material around the impression copings and takes a pick-up impression. Together with the previously recorded wax bite of the interocclusal relationship, the impression is sent to be poured in the laboratory as a master cast with the accompanying analogs (Fig 10-30d). After the impression is taken, the clinician places healing caps to protect the abutment and dismisses the patient, who will return within 48 hours for a try-in of the metal frame.

Laboratory procedures and try-in of prosthesis

With the castable UCLA abutments, the laboratory prepares a metal frame (Figs 10-30e and 10-30f) on which acrylic resin or ceramic teeth will be seated. When the prosthesis is long, it should be cut in two parts to facilitate passive seating. Within 48 hours, the prosthesis, or both parts of it, is tried in the patient's mouth. The prosthetic teeth are then attached to the metal frame (Fig 10-30g).

Seating of prosthesis

The final prosthesis is tried in the patient's mouth to verify its passive fit (Fig 10-30h). If the seating is correct, the gold screws are tightened at a torque of 20 Ncm and the access holes are sealed with acrylic resin. Figures 10-30i and 10-30j show the prosthesis in the mouth and the patient's smile.

Control radiograph

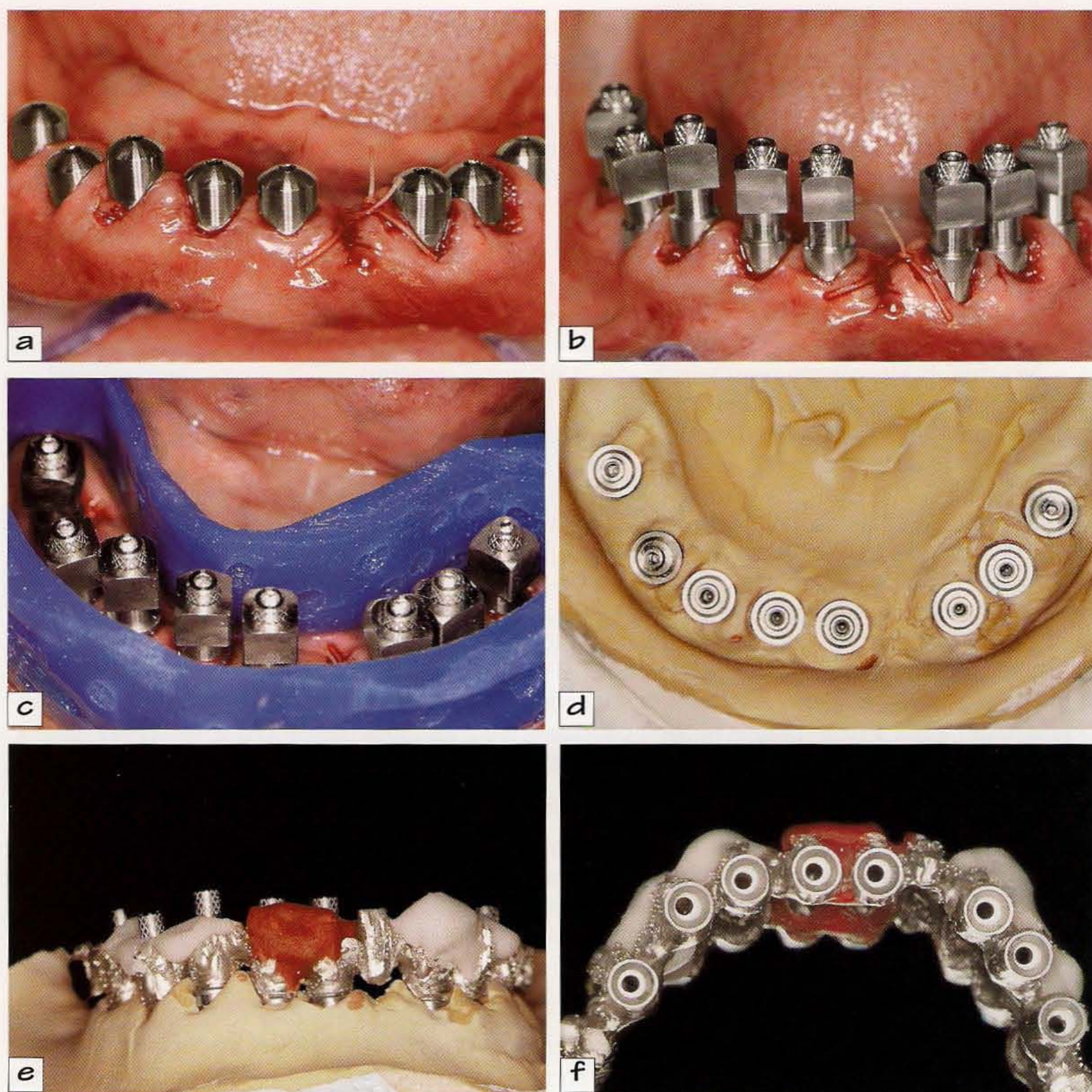
A radiograph is taken to verify the seating of the prosthetic components and to observe the baseline status of crestal bone (Fig 10-30k).

Treatment variants

In the case chosen to illustrate option 3, eight implants were placed, all in alveoli of extraction sites. The situation most frequently described in the literature is the treatment of an already edentulous mandible with five or six implants placed in the anterior segment. However, it is possible to adapt the number of implants and their distribution in response to individual needs. For example, the final prosthesis may be seated directly on the implant neck or on intermediate transgingival abutments.

Variant 1: Use of surgical guide to take impression

In one case of variant treatment, six implants were placed in healed anterior sites (Figs 10-31a to 10-31c). One of the distinguishing features of this case was the use of the surgical guide to take the impression.



▲▲ **Fig 10-30** Edentulous mandible treated according to option 3. This case has already been used to illustrate the placement of implants in extraction sites (see Figs 10-9 and 10-10). (a) Beginning of the prosthetic phase. The patient had healing caps on the transgingival IOL abutments. (b) Impression copings seated after removal of the healing caps. (c) Try-in of the impression tray. Later a sheet of wax or surgical tape is placed over it to prevent the impression material from flowing out of the tray. (d) Cast with the abutment analogs in place. (e) Try-in of the metal frame on the cast. The metal frame has been cut into two sections so that it will seat passively. (f) Interior surface of the frame. Note the presence of UCLA abutments corresponding to the transgingival abutments. (g) Try-in of the metal frame. If the seating is not sufficiently passive, the pattern resin can be removed and the two segments realigned. (h) Final prosthesis screwed to the implants. (i) Buccal view of the prosthesis in place. The transgingival abutments are visible. Soft tissue healing has been satisfactory, especially in the extraction sites. Opened embrasures have encouraged good maintenance of oral hygiene. (j) Patient's smile after insertion of the final prosthesis, 3 days after surgery. With this type of smile line that masks the mandibular prosthesis, there is no cosmetic need to hide the emergence of abutments from the gingiva. (k) Control radiographs. Note the "sleeping" implant placed in the anterior segment, the transgingival abutments, and the metal frame. (Prosthesis by Dr E. Hazan and J. Binois.)

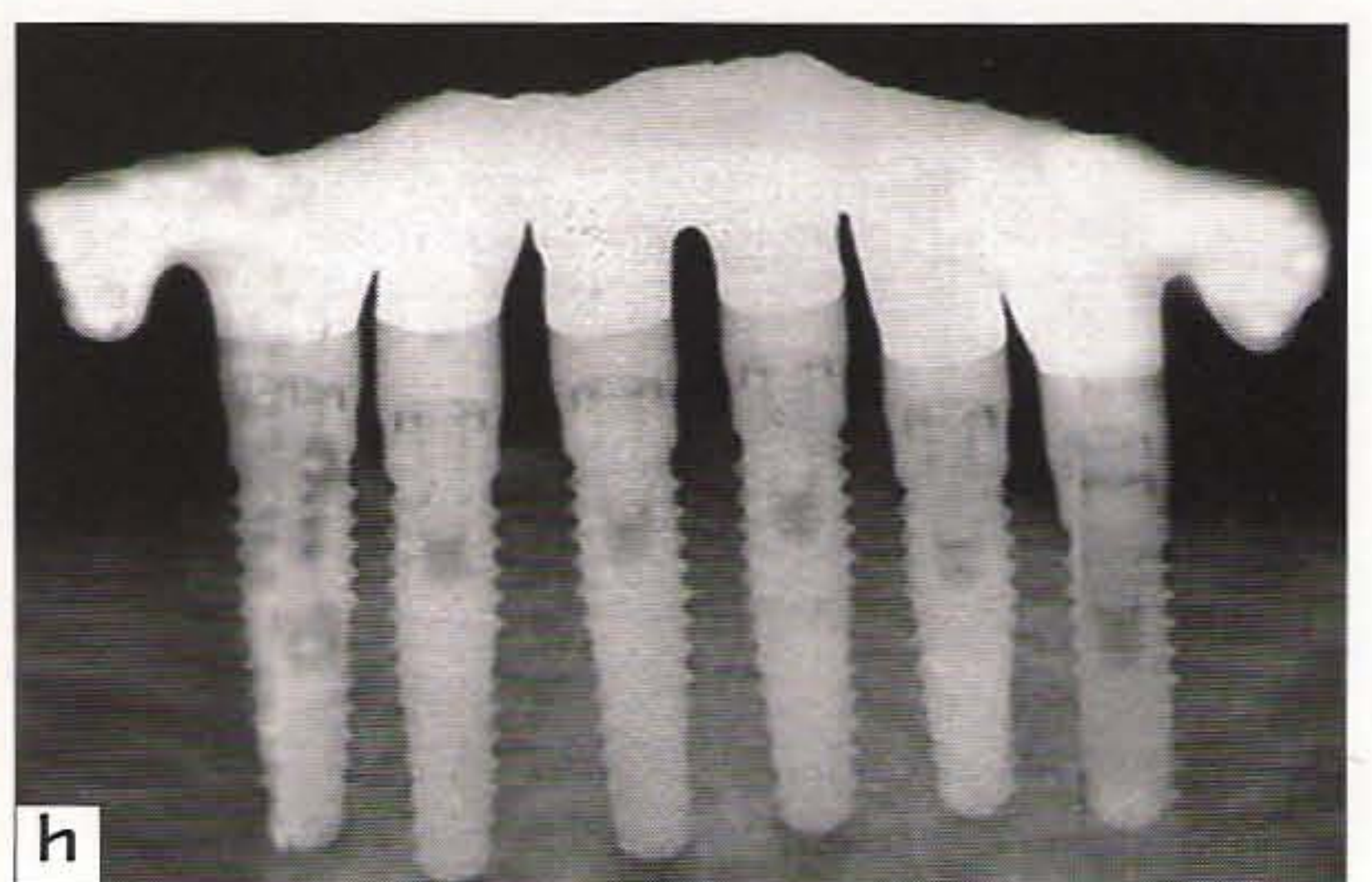


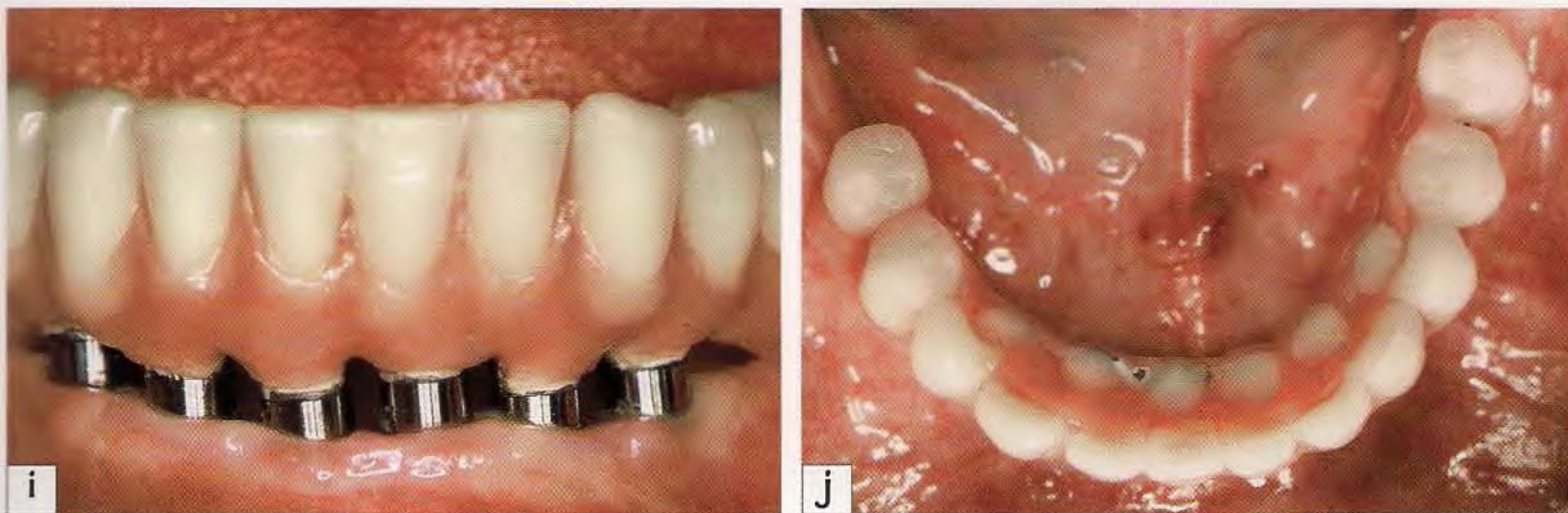
Because bone resorption of the mandible was advanced, 4-mm-high transgingival IOL abutments were placed on the implant neck to elevate the prosthetic plane (see Fig 10-31c).

The surgical guide (Fig 10-31d), hollowed in the anterior region, can serve as an individualized impression tray. In this case, the guide was made in autopolymerizable resin from a cast of the prosthesis the patient had been wearing (Fig 10-31e). If some posterior teeth are left in place on the surgical guide, the impression can perform double duty as a bite registration as well. The laboratory then pours the working cast (Fig 10-31f).

The laboratory mounts the waxup of the metal frame on the castable UCLA abutments with a gold base (Fig 10-31g). The waxup is cast and then tried in, first on the cast and then in the mouth. If it fits properly, the laboratory attaches the prosthetic teeth on the frame, completing the final metal-reinforced distal-extension prosthesis. Open embrasures were established to help this patient, who was a smoker, maintain good oral hygiene.

A radiograph taken when the final prosthesis was delivered revealed the metal frame, and its extensions, seated on the titanium abutments (Fig 10-31h). Figure 10-31i shows the excellent condition of the soft tissues after 6 months, which was facilitated by good oral hygiene encouraged by the generous embrasures. The prosthesis had to be remade when some acrylic resin teeth fractured (Fig 10-31j).





◀ ▲ **Fig 10-31** Edentulous mandible treated with variant 1 of option 3. (a) Preoperative view of the edentulous mandible. (b) Radiograph of the edentulous mandible. Bone resorption is severe, especially in posterior quadrants. (c) Conventional situation of six implants placed in healed anterior sites. To raise the prosthetic plane to an acceptable level, 4-mm-high transgingival abutments are used. (d) Surgical guide. A duplicate of the reconstruction wax-up, it has been opened in the region between the two mental foramina. The occlusal patterns in the posterior segments will facilitate registration of the interocclusal relationship. (e) Impression taken with the surgical guide. With this technique, the number of components prepared by the laboratory is reduced. The occlusal patterns in the posterior segments of the guide facilitate repositioning of the impression. (f) Cast poured from the impression. Note the analogs of the IOL abutments. (g) Wax-up mounted on the base of the castable UCLA abutments with gold bases. Note the presence of extensions. (h) Control radiographs. Note the abutments above the implants and the more radiopaque metal frame. (i) Six-month control for the final prosthesis. The clearly visible IOL abutments with the large embrasures have contributed to the health of the surrounding soft tissues. (j) Twelve-month control. The prosthesis had to be entirely remounted after fracture of the acrylic resin teeth. The implants are lingual to the prosthetic teeth because of severe bone resorption. (Prosthesis by Dr B. Jakubowicz-Kohen.)

Variant 2: Implants placed distal to mental foramen

In this case, eight implants were placed in primarily healed posterior sites. The anterior mandibular ridge of the patient was narrow, and the remaining anterior teeth were almost totally denuded of supporting bone (Figs 10-32a and 10-32b), but the posterior ridges had sufficient height to receive implants. Therefore, eight implants were placed in healed and extraction sites (Fig 10-32c).

To ensure that a fixed complete mandibular prosthesis will be correctly retained by implants placed in posterior segments when anterior support is inadequate, the prosthesis must be constructed on a metal frame (see Figs 10-32a and 10-32b). In this case, an impression was taken directly on the implants and sent to the laboratory (Fig 10-32d).

The final prosthesis was constructed with a metal frame made from castable UCLA abutments resting directly on the implant necks; there was a small extension on the left side (Fig 10-32e). The prosthesis was not supported by any implants in the region of the symphysis (Figs 10-32f and 10-32g).

For cosmetic reasons, the patient did not wish to have embrasures that would be too visible (Fig 10-32h). She was urged to be scrupulous in maintaining good oral hygiene with toothbrushing and water jet.

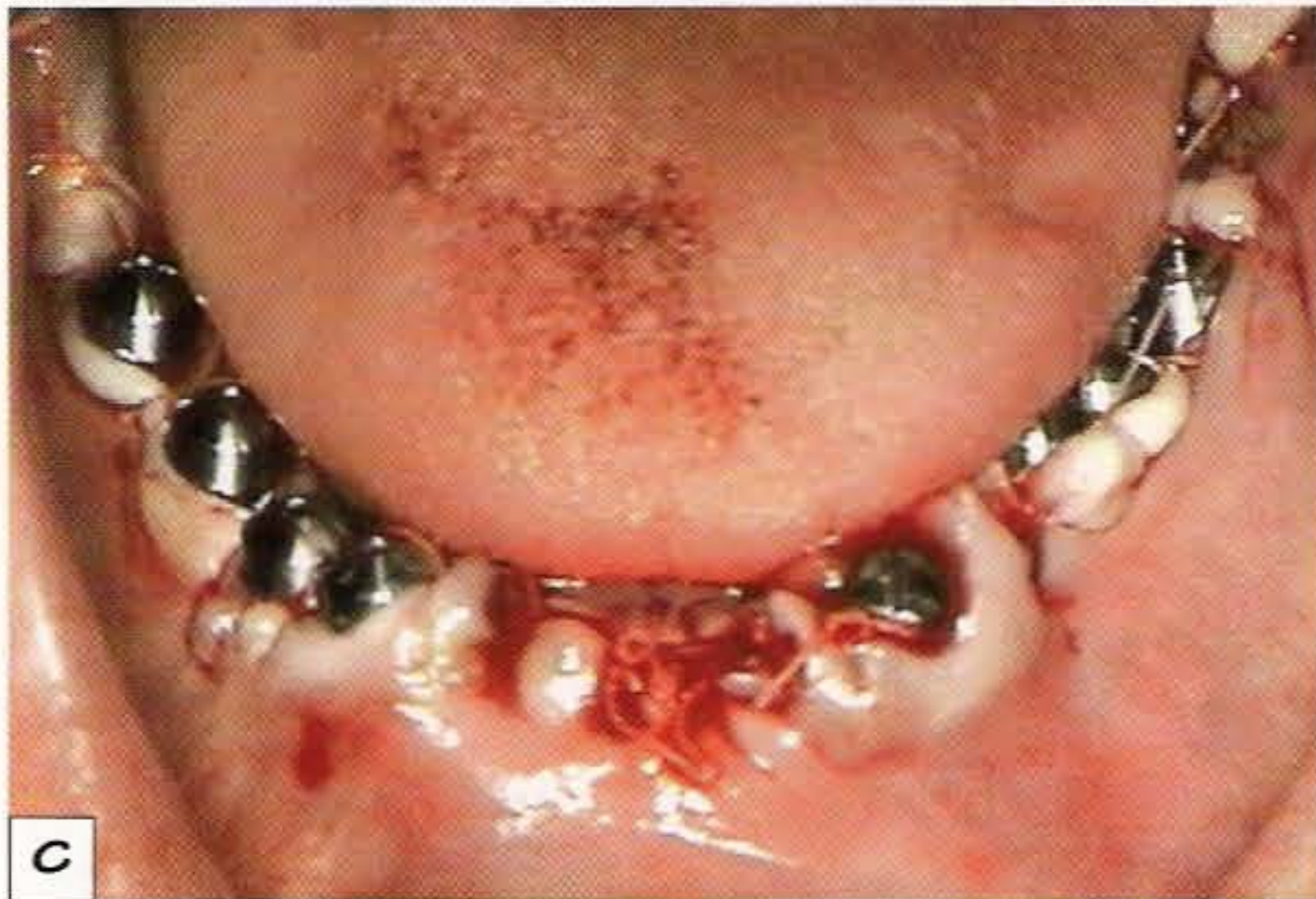
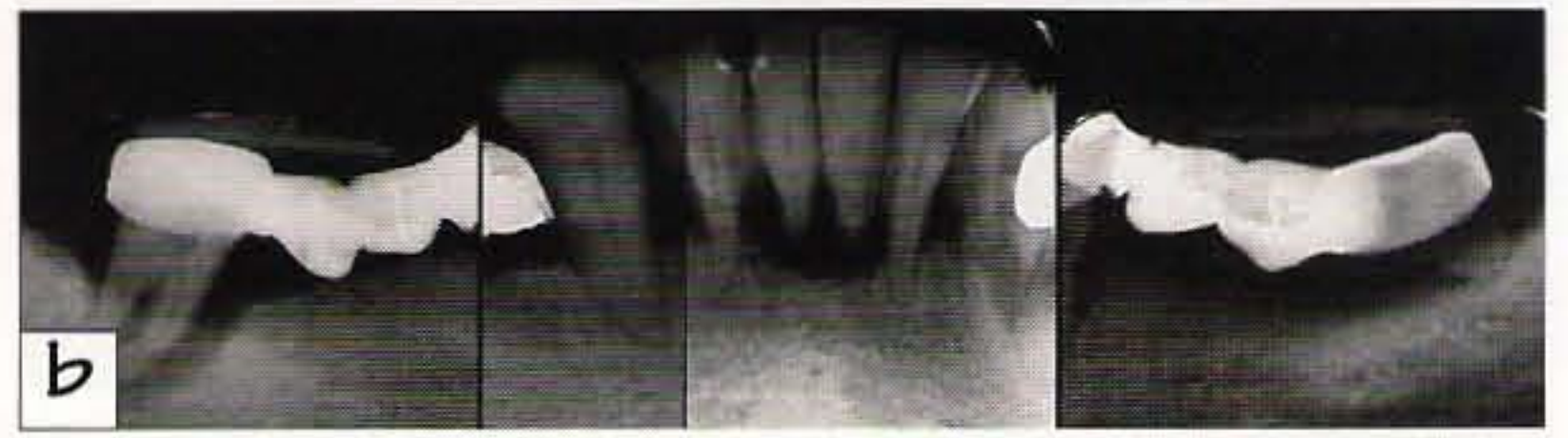
A radiograph taken when the final prosthesis was inserted revealed the metal frame resting directly on the implants (Fig 10-32i). At the 12-month examination, the gingival tissues were in satisfactory health (Figs 10-32j to 10-32l).

Control visits

Patients are advised to eat soft foods for the first 6 to 8 weeks after the prosthesis has been placed.

Patients undergo follow-up examinations:

- At 1 day, the occlusion is evaluated and the start of healing is assessed.
- At 10 days, the health of the soft tissues is evaluated and sutures are removed.





◀ ▶ **Fig 10-32** Edentulous mandible treated with variant 2 of option 3, with implants placed in the posterior quadrant. (a) Preoperative view. (b) Preoperative radiographs. Advanced anterior bone resorption makes the ridge in that region too narrow to receive implants. (c) Postoperative view. Eight implants with healing abutments have been placed primarily in posterior sites. (d) Impression taken directly on the implant necks. Note the impression copings for implants with internal connection. (e) Interior surface of the prosthesis. The metal frame of the prosthesis rests directly on the implant necks without the interposition of abutments. A metal frame is absolutely necessary to ensure satisfactory stability when only one anterior implant is present (located in the canine area). (f) Soft tissues at the time of prosthesis delivery. (g) Final prosthesis. Note the arrangement of the screw access paths and the absence of any implants in the symphyseal region. (h) Buccal view of the prosthesis. For cosmetic reasons, open embrasures were not created between the implants. (i) Radiographs taken after delivery of the final prosthesis. Note the demarcation between the more radiopaque metal frame, which is made of precious metal, and the titanium implants as well as the anterior metal bar, which is devoid of implant support. (j) Patient's smile at the 12-month control visit. (k) Buccal view of the prosthesis at 12 months. The patient is a smoker. (l) Lateral view at 12 months. Note the health of the gingiva at the emergence of the abutments. (Prosthesis by Dr E. Cohen.)

- At 1 month, the quality of soft tissue healing is assessed and the examination should confirm that the patient is asymptomatic. It is not necessary to check implant stability either manually with percussion or with a testing device such as Periotest or Osstell. If there is a specific reason for doing so, the prosthesis can be unscrewed at this visit. This manipulation does not interfere with bone repair, but it is by no means routinely indicated.
- Between 2 and 4 months, depending on whether the implants were placed in healed or extraction sites, the osseointegration is assessed. This assessment is described in detail later in the chapter.

Management of complications

Complications can arise during the surgical phase, during the prosthetic phase, or after delivery of the provisional or the final prosthesis. Complications may be common to all options or specific to a given prosthetic option.

Complications during the surgical phase

Complication common to all surgical options

Insufficient primary stability

If primary stability is inadequate (ie, less than 35 Ncm) especially for the most anterior and most distal strategically important implants, it is advisable to abandon the implementation of immediate loading.

At this time, it is still possible to consider substituting a longer or larger implant for the defective one or to add supplementary implants that could achieve primary stability.

Figures 10-33a to 10-33c illustrate a situation where implant primary stability was unsatisfactory. A 4-mm-diameter implant was placed in the alveolus of an extracted tooth (Fig 10-33a). Its stability was less than 30 Ncm, proving to be insufficient. The implant was removed; the site was enlarged to receive a 5-mm-diameter implant (Figs 10-33b and 10-33c). As a result, the residual thickness of the plate was less than 1 mm, but this was not troubling because the esthetic requirements in this case were negligible and primary stability was the essential consideration.

Complications during the provisional prosthetic phase

Complications common to all prosthetic options

Slight discrepancy in parallelism of implants

A lack of parallelisms is the most frequent problem. A difference in the angulation of implants may make it necessary to seriously enlarge the openings in the prosthesis, enough to necessitate removal of one or more prosthetic teeth. This complication can be managed by one of two methods:

1. The obstructing tooth is removed and openings large enough to seat the prosthesis are created. The tooth is replaced after the prosthesis has been seated and the cylinders have been ground flat.
2. The metal cylinder is ground so that the opening in the prosthesis will not have to be greatly enlarged to receive it. However, this must be performed carefully so that the cylinder is not abraded beyond the edge of the acrylic resin.

Substantial discrepancy in angulation of implants

If the differences in angulation between implants are too great, enlarging the holes to accommodate the cylinders may result in the removal of so much resin from the prosthesis that it becomes weak and liable to fracture.

Failure to achieve passive fit

This problem can result from:

- An inadequate impression (options 1 and 2)
- Excessive shrinkage of the acrylic resin as it hardens around the provisional cylinders (options 1 and 2)
- An error in the laboratory procedures (options 1 and 3)

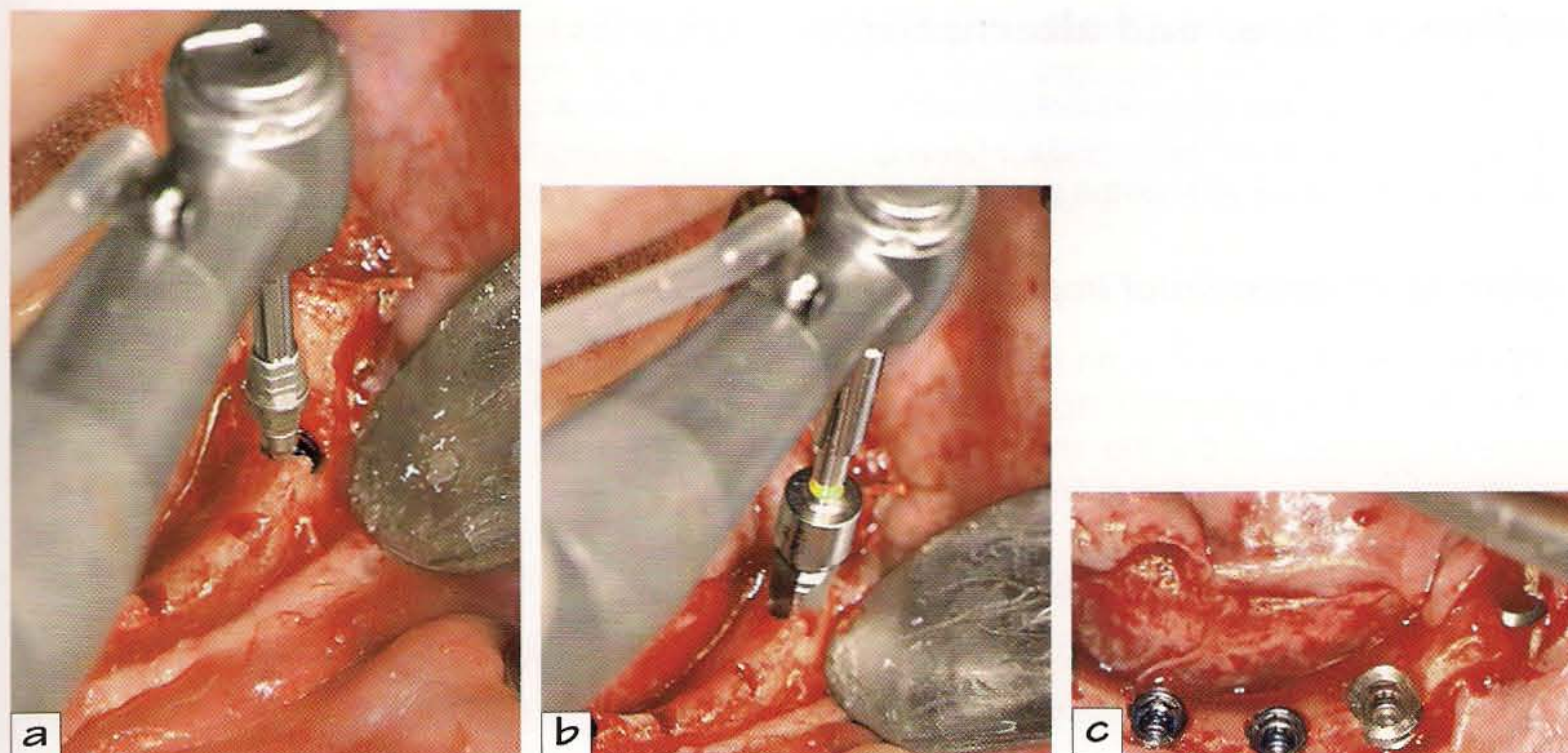
If the clinician is attaching the prosthesis to the cylinders in the mouth, failure to achieve passive seating will mean that the cylinders must be detached and the procedure repeated.

If the laboratory is effecting the attachment, the clinician must take a new impression and the laboratory will have to repeat the process. New cylinders should be used because the originals have been ground and polished and may be not be reliable for a reattachment.

Complication specific to treatment options 1 and 3

Fracture of impression transfer screw in abutment

Fracture can occur when the impression transfer screw is not the same length as the abutment. If it breaks, the abutment is removed and another abutment is placed.



▲ **Fig 10-33** Complication during the surgical phase. A 4-mm-diameter implant is replaced with a 5-mm-diameter implant to improve primary stability. (a) A 4-mm implant (*blue neck*) has been placed in the alveolus of an extracted tooth. The implant stability is less than 35 Ncm, which is insufficient. (b) Drilling with a larger bur (*yellow neck*). (c) A 5-mm implant (*gold neck*) has been placed and has obtained the necessary primary stability. Because esthetics is not a concern, achieving primary stability is more important than adhering to the rules of 3D implant placement, which are usually paramount in esthetic sites.

Complications specific to treatment option 2

Patient fatigue

If the patient begins to fidget or tire in the chair, it might be advisable to suspend the procedure and deliver the prosthesis the next day. Alternatively, it might be preferable to have the laboratory attach the prosthesis. For the latter choice, the prosthodontist takes a twist lock or a pick-up impression with the best-fitting available tray and a wax bite registration of the interocclusal relationship. These are sent to the laboratory, which will attach the prosthesis to the cylinders. Healing caps are placed on the implants and removed the next day when the prosthesis can be readily seated in the patient's mouth.

Fracture of prosthesis during preparation for cylinders

Because the prosthesis is weakened by hollowing, fracture of the prosthesis is not unexpected when the existing prosthesis was not specifically made for the conversion procedure. A new prosthesis, prepared just for the occasion with buccolingual reinforcements, will be less sensitive to this type of complication.

Complications after delivery of the prosthesis

Complication common to all prosthetic treatment options

Fracture of acrylic resin teeth in conversion prosthesis or final prosthesis

This complication has been frequently described in the literature. The clinician must determine what occlusal forces have loosened or broken the tooth or teeth. When these forces are identified and eliminated, the prosthesis is returned to the laboratory for replacement of the broken or missing teeth. Such repair is easy.

Complication specific to treatment options 1 and 2

Fracture of the prosthesis during the provisionalization period

The fractured prosthesis can be sent to the laboratory to be repaired. If necessary, the prosthesis can be strengthened with a metal reinforcement.

Implant failures and alternative treatments

Implants rarely fail during the provisional prosthetic phase for this indication. Many authors have reported 100% success rates for this immediate-loading protocol.^{12,22,23} Failures, when they occur, result from an error made by the surgeon or the prosthodontist and can be easily identified and resolved.

Failure of an unessential implant

When the clinician finds that an implant unessential to the function of the provisional prosthesis is mobile, the implant should be rapidly removed or unloaded (see chapter 8). The corresponding site on the prosthesis without the implant is filled with acrylic resin. The patient uses this adjusted provisional prosthesis until the final one is ready.

Failure of an essential implant

Most frequently, when an implant essential to the function of the provisional prosthesis fails, it is a distal implant that becomes mobile. After it is removed, a new implant can be placed immediately. Depending on circumstances, the new implant can be placed in one of two sites:

1. The same failed site, when it is feasible to place a wider and, if possible, longer implant with a primary stability greater than or equal to 35 Ncm. The first step is removal of any fibrous tissue and redrilling of the alveolus. The new implant can be loaded immediately and the patient can continue to wear the provisional prosthesis.
2. A site near the failed implant, either mesial or distal to it. This new implant also can be loaded immediately, after the laboratory has adjusted the prosthesis to receive the new implant. The patient then continues with the provisional prosthesis as planned.

To prevent this type of problem from arising, it is best not to plan immediate loading when only three or four implants are available to support the prosthesis, contrary to what has been suggested in the literature.^{6,19,28,29} With so few implants, the loss of a single one could jeopardize the stability of the prosthesis. Patients can easily accept the loss of a single implant if provisional restoration with a fixed prosthesis is not compromised.

Failure of several implants

The authors have never observed failure of multiple implants, destabilizing the prosthesis, in the edentulous mandible. Likewise, this situation has never been described in the literature for protocols stipulating five or six implants.

Final prosthetic phase

In option 3, the final prosthesis is delivered within 72 hours after placement of the implants, but with the other options the patient is first provided with a provisional prosthesis. With options 1 and 2, the conversion prosthesis procedure, the final prosthetic phase can begin 2 months after implant placement but it can also be performed at a later time. When implants have been placed in extraction sites, a 3- to 4-month wait is advisable.

Implant osseointegration is verified radiographically and clinically. Radiographically, osseointegration is evidenced by the absence of a dark, radiolucent area around the implant. Clinically, the implant is:

- Tested manually for mobility
- Assessed for the presence or absence of any clinical sign such as pain or local inflammation
- Tested with application of a 20 Ncm countertorque
- Assessed with the Periotest or the Osstell to measure implant stability (see chapter 4)

When the soft tissues are in good health and there is no other sign of pathology, the final prosthetic stage can start. The final prosthesis is usually screw retained, like the provisional prosthesis. The final prosthesis can rest directly on the implant neck or on transgingival IOL abutments.

The clinician unscrews the provisional prosthesis or both the prosthesis and the abutments. After the implant impression copings or the abutment impression copings are attached to the implants, an impression and a wax bite are made in the usual way and sent to the laboratory.

The laboratory prepares a metal frame and mounts acrylic resin or ceramic prosthetic teeth. At this time, if the anteroposterior distance allows, extensions can be added to the prosthesis if this has not already been done in the provisional phase.

The clinician places the completed prosthesis in the patient's mouth, adjusts the occlusion, and takes a radiograph of the final prosthesis.

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TREATMENT OF THE EDENTULOUS ANTERIOR MAXILLA

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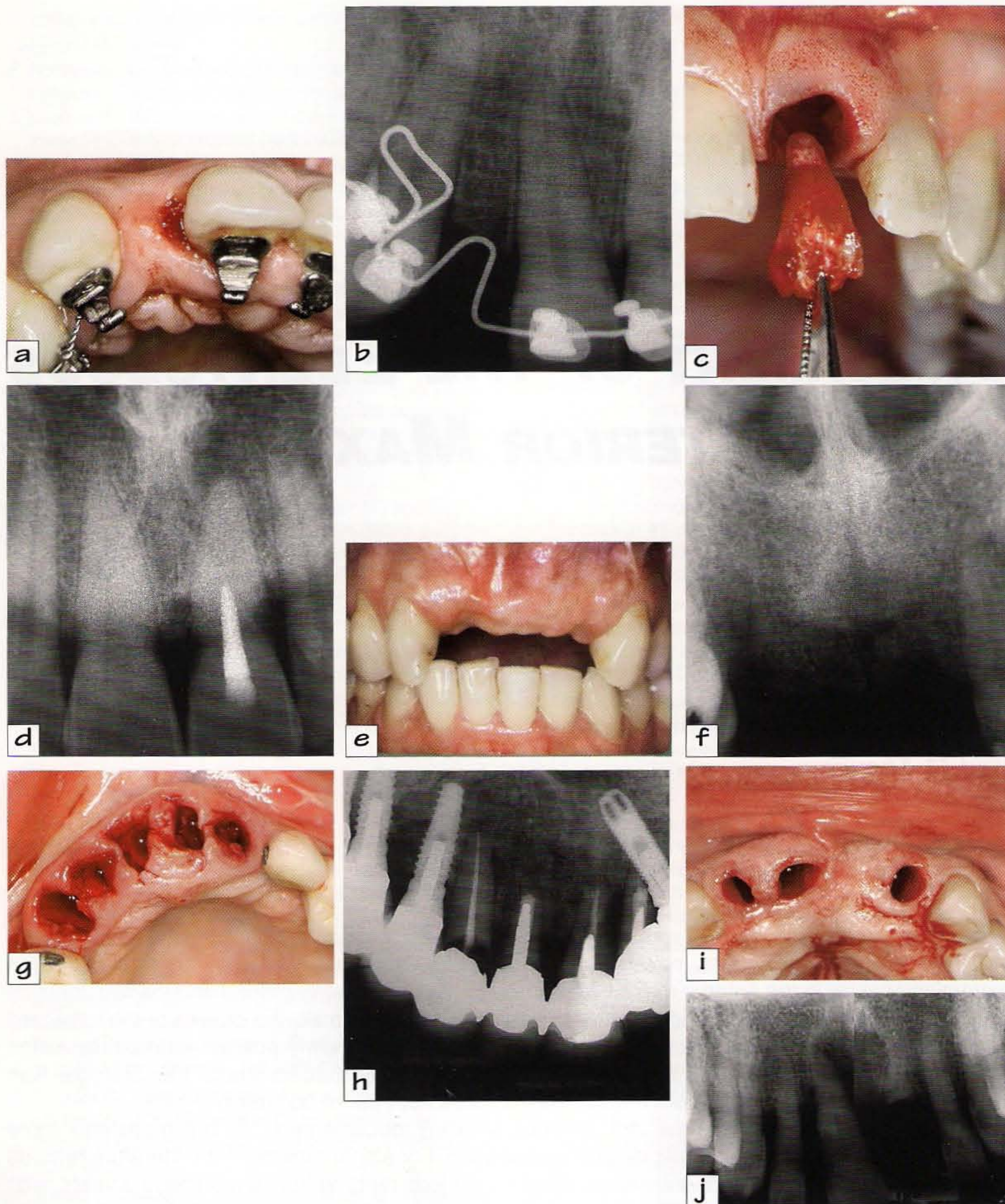
Historically, immediate loading was used in the maxillary anterior region after the good results obtained with the procedure in edentulous mandibles and maxillae were confirmed. Single extraction sockets in the anterior maxilla were treated with immediately placed and loaded implants in order to alleviate the psychologic distress of patients.^{1,2} Sometimes, the crowns of the extracted or avulsed natural teeth were hollowed and cemented over the newly positioned implants. Later, implants were also placed in healed sites and immediately loaded. Next, the protocol was expanded to short-span fixed partial dentures that were kept out of occlusion.

These various indications have not all been similarly documented,¹⁻²³ but more and more studies with 3 or more years of follow-up are appearing. For single crowns,²⁴ the literature records 556 patients with a total of 625 implants in place for periods ranging from 6 months to 3 years, with an average success rate of 97.0%. Documentation for short-span fixed partial dentures is more limited²⁴; there are published records of 44 patients with 124 implants that have been in place for 1 to 2 years; the reported success rate is 93.6%.

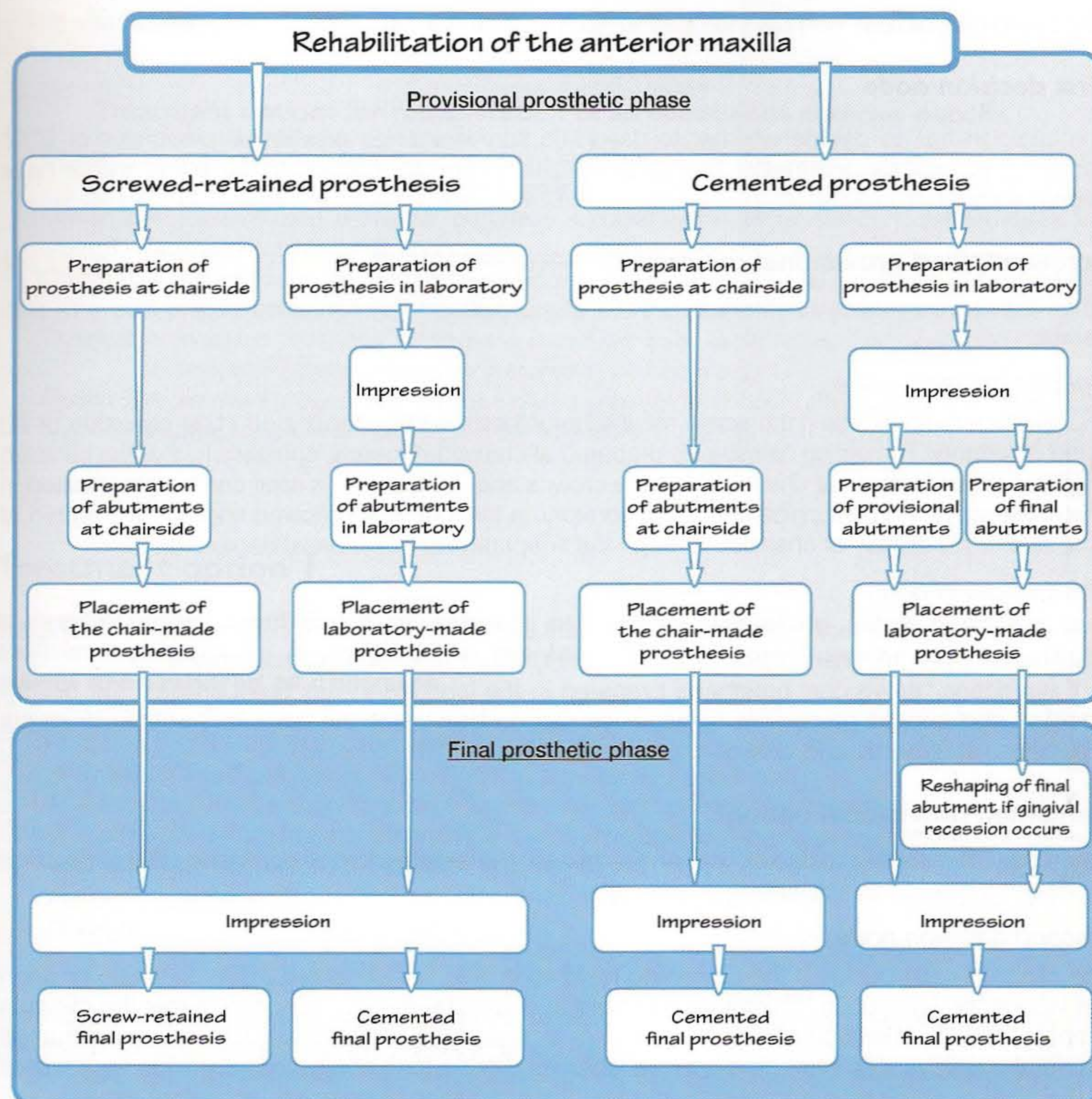
Treatment of the edentulous anterior maxilla includes:

- Rehabilitation of a single tooth in healed sites (Figs 11-1a and 11-1b)
- Rehabilitation of a single tooth in extraction sites (Figs 11-1c and 11-1d)
- Rehabilitation of multiple teeth in healed sites (Figs 11-1e and 11-1f)
- Rehabilitation of multiple teeth in extraction sites (Figs 11-1g and 11-1h) or in mixed healed and extraction sites (Figs 11-1i and 11-1j)

These approaches to management of these varied situations are similar, which is why they are all discussed in the same chapter. However, their differences will be emphasized as well as the specific problems that might be encountered with each.



▲ **Fig 11-1** Clinical conditions included in the term *edentulous anterior maxilla*. (a and b) Single crown in a healed site. (a) Clinical view. (b) Radiograph. (c and d) Single crown in an extraction site. (c) Clinical view. (d) Radiograph. (e and f) Fixed partial denture in healed sites. (e) Clinical view. (f) Radiograph. (g and h) Fixed partial denture in extraction sites. (g) Clinical view after extraction. (h) Radiograph before extractions. (i and j) Fixed partial denture in mixed healed and extraction sites. (i) Clinical situation after extraction. (j) Radiograph before extractions.



▲ **Fig 11-2a** Decision tree showing all treatment options available to rehabilitate the anterior segment of the maxilla. These options are common to healed and extraction sites.

▼ Treatment Options

The scope of the treatment options is outlined in Fig 11-2a in the form of a decision tree with successive decisions nodes. The decision tree is similar for both healed and extraction sites. The sole difference lies in the fact that the hollowed crowns of extracted teeth can be used for implant-supported restorations when their integrity is sufficient.

Decision nodes

First decision node

The clinician has to decide whether to use (1) a screw-retained provisional prosthesis or (2) a cemented provisional prosthesis. The data the clinician should evaluate to make this choice have been discussed in chapter 7.

Screw-retained provisional option

When the "screw-retained" option is chosen, the prosthodontist continues on the tree with new decision nodes.

Second decision node

The clinician must decide if the screw-retained prosthesis is to be fabricated (1) at chairside or (2) in the laboratory. The option "prosthesis prepared at chairside" means, specifically, that the clinician prepares the abutments at chairside, but the crowns and the prosthesis itself can be constructed in one of two ways: (1) presurgically, in the laboratory, in the form of a hollowed shell to be adapted at chairside or (2) directly at chairside through the adaptation of commercial denture teeth.

Third decision node

After completion of osseointegration, when implant stability has been clinically verified, the clinician must determine if the final prosthesis should be (1) screw retained or (2) cemented.

If the option "provisional prosthesis prepared in the laboratory" has been chosen, the prosthodontist, after implant placement, takes an impression from which the laboratory will construct the prosthesis, abutments, and crowns.

Cemented provisional option

When the "cemented prosthesis" option is chosen, the prosthodontist continues on the decision tree with new decision nodes.

Second decision node

The clinician must decide if the cemented restoration is to be fabricated (1) at chairside or (2) in the laboratory. The option "prosthesis prepared at chairside" means, specifically, that the clinician prepares the abutments at chairside, but the crowns and the prosthesis itself can be constructed in one of two ways: (1) presurgically, in the laboratory, in the form of a hollowed shell to be adapted at the chair or (2) directly at chairside, through the adaptation of commercial denture teeth.

After the prosthesis has functioned for 6 months, which is the time required for maturation of the soft tissues, the clinician evaluates implant stability before beginning the final prosthetic phase.

The abutments that were placed after surgery are unscrewed before the taking of an impression, from which the final cemented prosthesis will be fabricated.

Third decision node

If the prosthesis is to be prepared in the laboratory, the clinician must make another decision: whether to install (1) provisional abutments, designed to be unscrewed and replaced during the final prosthetic phase, or (2) final abutments that, for the esthetic reasons discussed in chapter 6, will not be unscrewed any more, even for preparation of the final prosthesis.

After 6 months of function of the provisional prosthesis and soft tissue healing, the clinician checks implant stability before starting fabrication of the final restoration. If provisional abutments were placed, they are removed, and an impression is taken directly over the implant neck with impression copings in place. If the abutments are final, they are not unscrewed, and the clinician takes the impression on these abutments. If gingival recession has occurred, the clinician adjusts the cervical margins of the abutments in the mouth.

The various treatment options for the maxillary anterior segment will now be considered.

Treatment options for rehabilitation of an edentulous anterior maxilla

- Option 1: A screw-retained provisional prosthesis is placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the abutments are prepared at chairside.
- Option 2: A screw-retained provisional prosthesis is placed within 24 to 48 hours; the prosthesis is fabricated entirely in the laboratory.
- Option 3: A cemented provisional prosthesis is placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the abutments are prepared at chairside.
- Option 4: A cemented provisional prosthesis is placed within 24 to 48 hours after surgery; provisional abutments and the prosthesis are prepared in the laboratory.
- Option 5: A cemented provisional prosthesis is placed within 24 to 48 hours after surgery; final abutments and the prosthesis are prepared in the laboratory.

Treatment option I

Screw-retained provisional prosthesis placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the abutments are prepared at chairside.

This option (Fig 11-2b) is chosen when:

- A screw-retained prosthesis is preferred to a cemented prosthesis.
- The implants' axes are compatible with a palatal access paths for screws.
- The principal determinant of treatment is the psychologic well-being of the patient. The patient who would be uncomfortable appearing in public with a space in the maxillary anterior region is able to leave the office after surgery with an immediate replacement for the extracted tooth or teeth.

For this option, the laboratory fabricates shell teeth before surgery and the clinician attaches them to provisional cylinders prepared at chairside. Treated in one sitting, the patient leaves the office with the provisional fixed prosthesis in place.

Clinicians can use a variation of this treatment option by hollowing out a commercial denture tooth to make the acrylic resin shell at chairside, thus avoiding participation of the laboratory. This immediate-loading approach simplifies scheduling, because the availability of the laboratory does not have to be considered.

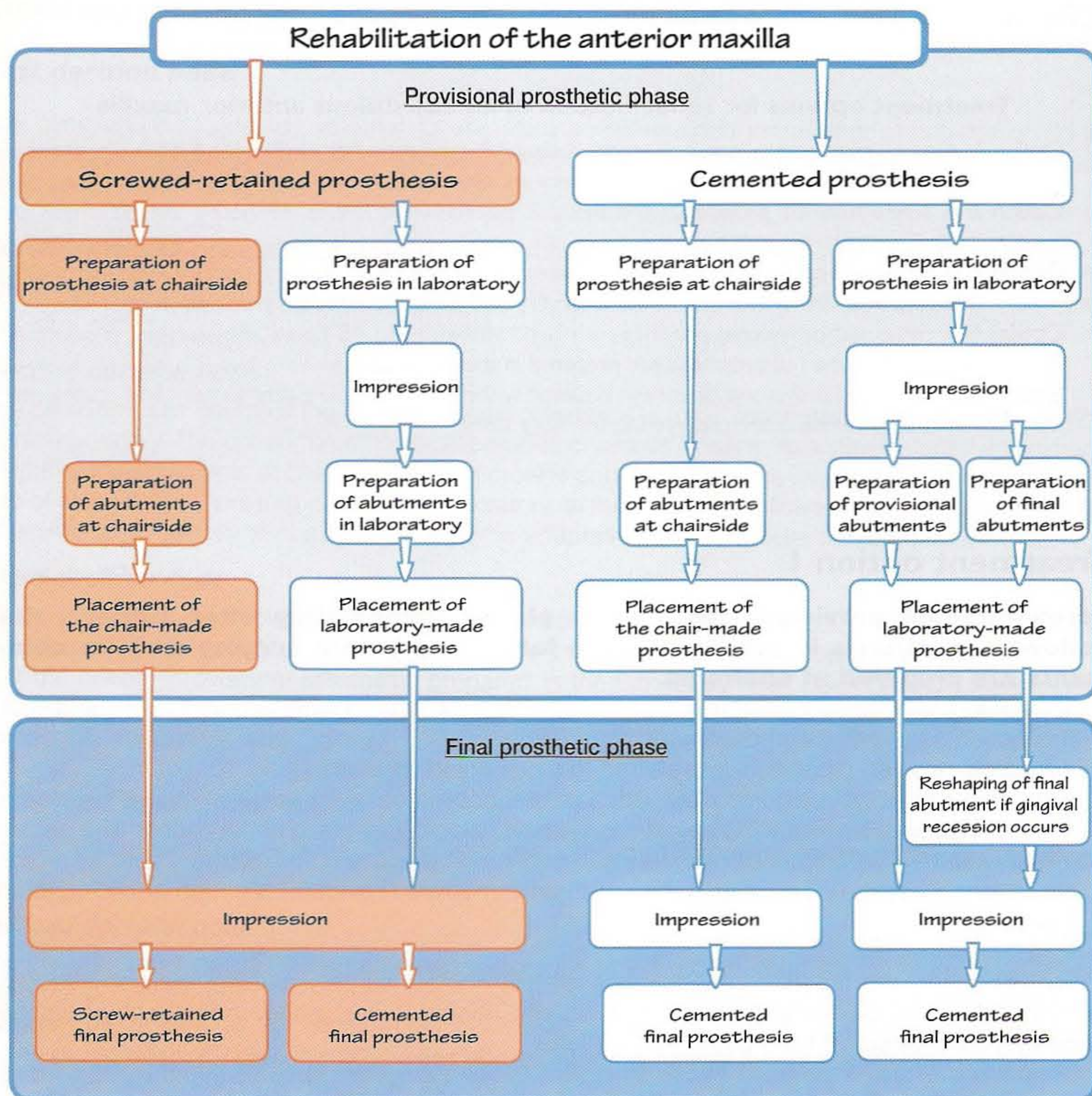
The provisional phase, during which osseointegration and soft tissue healing are completed, lasts for 6 months for both healed and extraction sites.

After successful osseointegration has been verified, a final restoration, either screw retained or cemented, is constructed in the laboratory from an impression taken in the conventional way. After the prosthesis is delivered to the patient, the clinician verifies the occlusion in the usual way.

Advantages

- The patient's psychologic needs are satisfied because the patient never has to appear in public without a restoration.
- The use of cement, which can irritate the soft tissue, is avoided.
- The clinician can easily remove the prosthesis to verify implant osseointegration.





▲ **Fig 11-2b** Treatment option to rehabilitate the anterior maxilla when a screw-retained provisional prosthesis is preferred and the principal determinant of treatment is the psychologic needs of the patient. The sequence of steps is indicated in red. The final prosthesis can be either screw retained or cemented.

Disadvantages

- The patient has to endure a lengthy combined session in the chair, including surgery and the consecutive prosthetic phase, which may last 2 to 4 hours.
- The clinician and the assisting team also endure a lengthy care session of 2 to 4 hours, especially if the surgical and prosthetic phases are carried out by the same practitioner.
- With this option, it is not possible to use a cast metal bar to reinforce the prosthesis (see Fig 4-12).
- The overall fee is greater than that charged for a laboratory-made prosthesis because of the protracted chair time the clinician must devote to the procedure.
- The screw-retained prosthesis may loosen.

Treatment tip:

This protocol must be chosen if the patient does not want to be deprived of a restoration, even for an instant. For patients who are not so demanding in this regard, a laboratory-made prosthesis simplifies the procedure for both the patient and the practitioner.

Treatment option 2

Screw-retained provisional prosthesis placed within 24 to 48 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

This option (Fig 11-2c) is chosen when:

- A screw-retained prosthesis is preferred to a cemented prosthesis.
- The implants' axes are compatible with palatal access paths for the retaining screw.
- The principal determinant of treatment is the patient's physical comfort. The patient does not want to endure a long session in the dental chair.
- It is desirable, for whatever reasons, to have the laboratory fabricate the prosthesis.
- Another principal determinant of treatment is longevity of the prosthesis. The incorporation of a metal frame in a prosthesis increases its capacity for resistance to fracture and prospects for longevity.

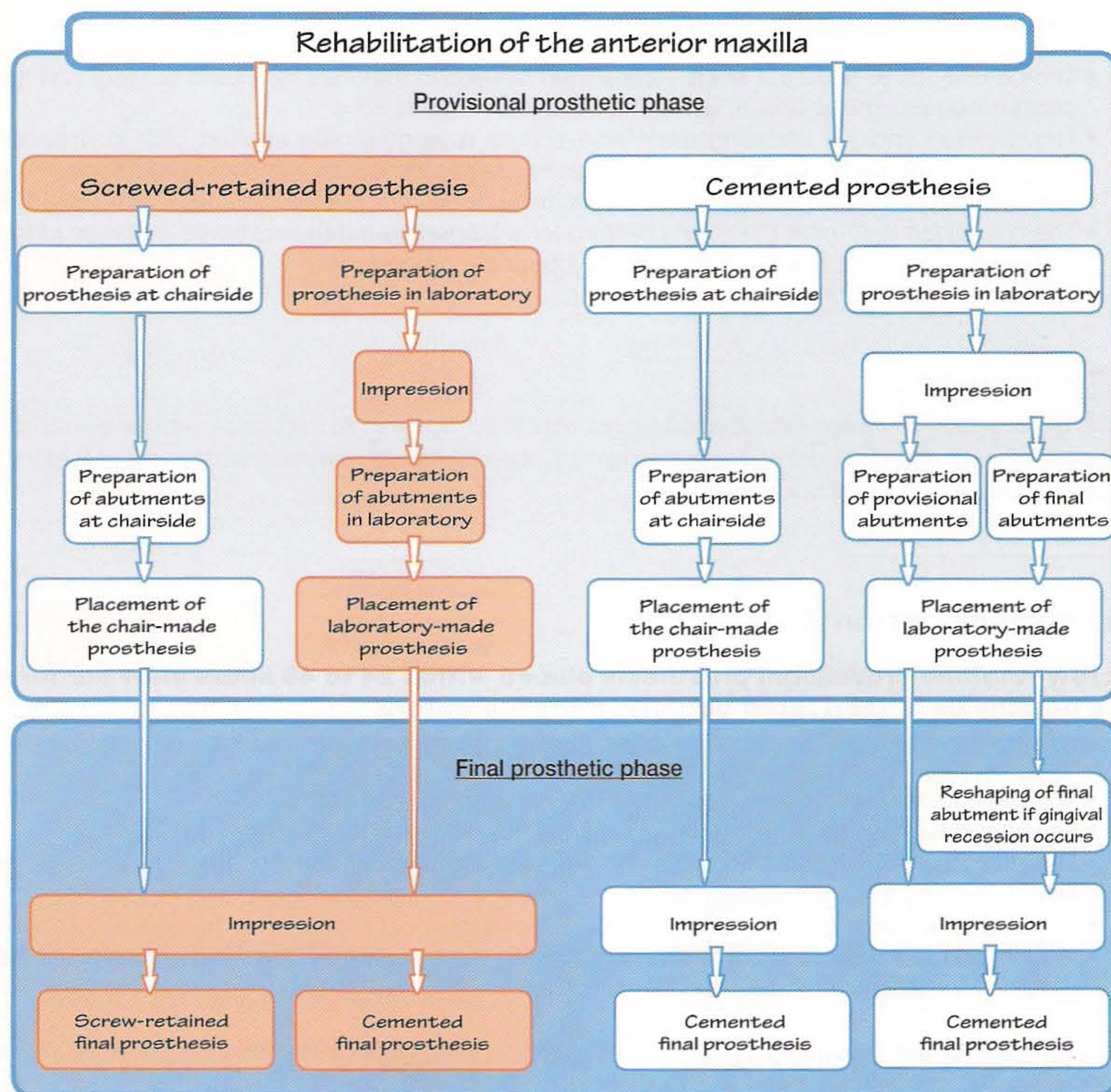
In contrast to the preceding option, in this option the prosthesis is fabricated entirely in the laboratory. The patient is treated in two distinct sessions and receives the restoration within 48 hours after surgery.

The prosthetic phase continues for 6 months, for both healed and extraction sites. During this time, osseointegration is obtained and soft tissues have matured.

After successful osseointegration has been verified, a final restoration, screw retained or cemented, is constructed in the laboratory from an impression taken in the conventional way. After the prosthesis is delivered to the patient, the clinician verifies the occlusion in the usual way.

Advantages

- The comfort of the patient is respected, because only the surgical phase is endured. The 1- to 3-hour prosthetic phase in the chair is avoided.
- The use of cement, which can irritate the soft tissue, is avoided.
- A cast metal reinforcement bar can be incorporated in a fixed partial denture (see Fig 4-12).
- The clinician can easily unscrew the prosthesis to verify implant osseointegration.
- The prosthodontist is spared a long and tedious session at chairside.
- The fee to the patient can be reduced because of the reduced chair time.
- With a metal framework, the provisional prosthesis is more resistant to fracture. It is reliable for a longer period than acrylic resin dentures, even those reinforced with a cast metal bar.



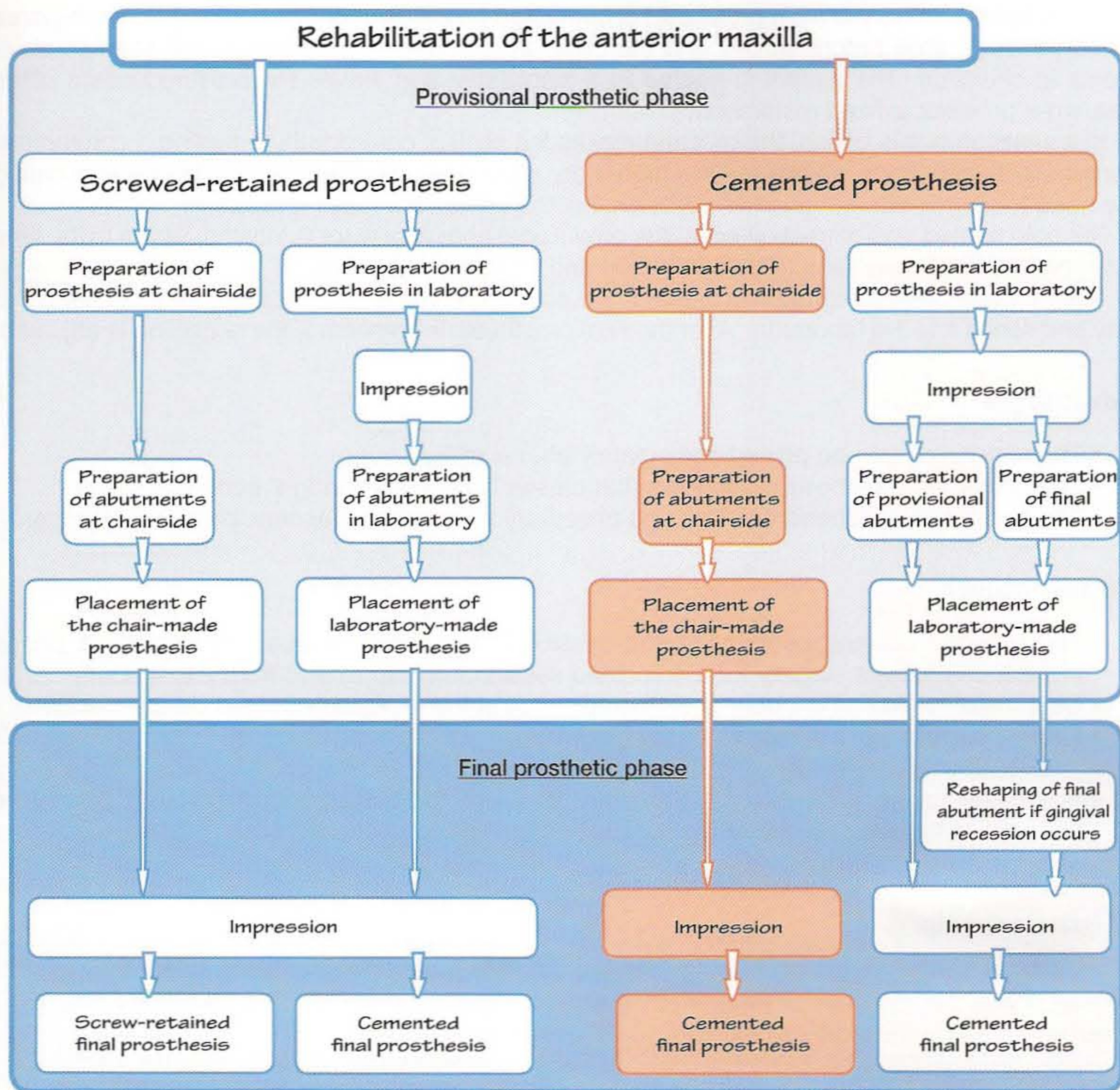
▲ **Fig 11-2c** Treatment option to rehabilitate the anterior maxilla when a screw-retained provisional prosthesis is preferred and the principal determinant of treatment is the physical comfort of the patient. The sequence of steps is indicated in red. The final prosthesis can be either screw retained or cemented.

Disadvantages

- The patient is deprived of a restoration for 1 or 2 days following surgery.
- If the wax bite registration is inaccurate the prosthetic procedure will have to be repeated.
- When a metal framework is used, the cost of the provisional prosthesis is increased.
- The risk of implant failure is not completely eliminated, despite the more expensive framework.
- The screw-retained prosthesis may loosen.

Treatment tip:

- This protocol is the one that should be chosen if a screw-retained provisional restoration is preferred.
- For prostheses, metal reinforcement, cast if possible, is recommended. When a metal frame is chosen to strengthen the prosthesis, the prosthodontist should select a laboratory that is experienced in the rapid and reliable fabrication of a metal frame.



▲ **Fig 11-2d** Treatment option to rehabilitate the anterior maxilla when a cemented prosthesis is preferred and the principal determinant of treatment is the psychologic needs of the patient. The sequence of steps is indicated in red. With this option, the final prosthesis is cemented.

Treatment option 3

Cemented provisional prosthesis placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the abutments are prepared at chairside.

This option (Fig 11-2d) is chosen when:

- A cemented provisional prosthesis is preferred over a screw-retained prosthesis.
- The principal determinant of treatment is the psychologic well-being of the patient. The patient who would be uncomfortable appearing in public with a space in the maxillary anterior region is able to leave the office after surgery with an immediate replacement for the extracted tooth or teeth.

In this option, an acrylic resin prosthesis is cemented on the abutments. The laboratory prepares an acrylic resin shell before surgery and the clinician attaches it to the provisional titanium abutments at chairside. The patient is treated in a single day and leaves the prosthodontist's office wearing a provisional fixed restoration.

In a variation of this option, the clinician makes the shell at chairside by adapting a commercial denture tooth and does not employ the laboratory at all. This simplifies scheduling by eliminating the need to coordinate with another participant in the immediate-loading protocol.

For both healed and extraction sites, the provisional phase lasts for 6 months, which is the time required for osseointegration to be completed and for soft tissues to heal.

After implant osseointegration is verified, the clinician takes an impression in the conventional way and sends it to the laboratory. After the final prosthesis is cemented, the occlusion is adjusted.

Advantages

- The restoration can be placed immediately after surgery.
- The cemented prosthesis conforms to the classic "crown and bridge" concept.
- The cemented prosthesis can be used effectively when implant access paths are divergent.

Disadvantages

- The patient must endure a protracted session in the chair, because the prosthetic phase immediately follows surgery for a combined session that can extend from 2 to 4 hours.
- Cast metal reinforcement cannot be incorporated in the prosthesis.
- Excess cement can be trapped in the gingiva.
- The prosthesis may debond.
- The costs to the patient are higher than they are for a laboratory-fabricated prosthesis because of the increased time the clinician has to spend at chairside.

Treatment tip:

This protocol is especially applicable to the fabrication of single crowns. For prostheses, especially when the implant access paths diverge, preparation of abutments may be intricate and it is prudent to have the laboratory fabricate the prosthesis indirectly.

Treatment option 4

Cemented provisional prosthesis placed within 24 to 48 hours after surgery; the provisional abutments and the prosthesis are prepared in the laboratory.

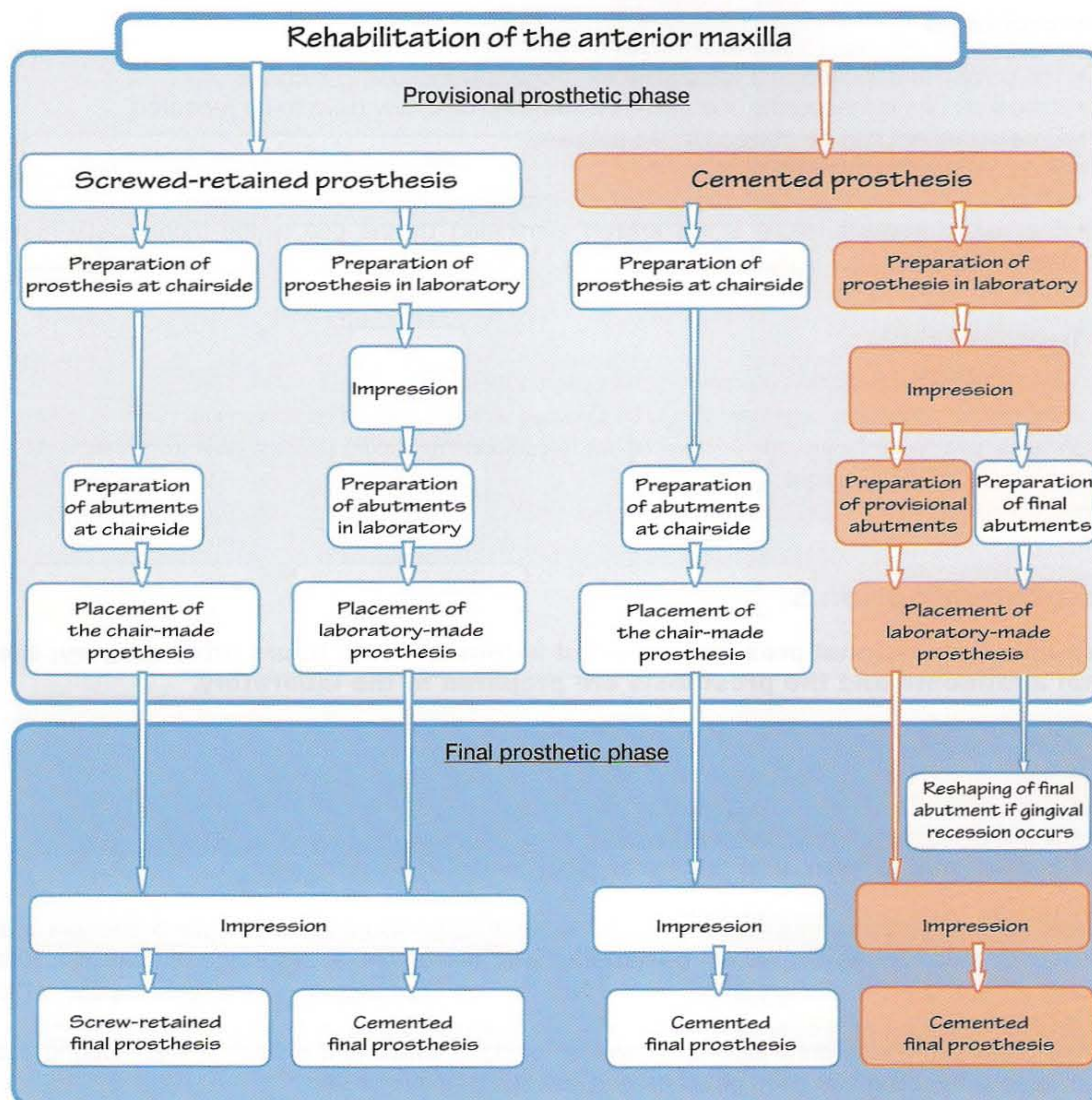
This option (Fig 11-2e) is chosen when:

- A cemented prosthesis is preferred over a screw-retained prosthesis.
- The physical comfort of the patient is the principal determinant of treatment.
- It is desirable, for whatever reason, to have the laboratory make the prosthesis.
- It is desirable to incorporate cast metal reinforcement in the prosthesis.

In contrast to the preceding option, in this option the laboratory assumes the entire responsibility for constructing the prosthesis. Patients are treated in two distinct, separate sessions. In the second, no later than 48 hours after surgery, the prosthodontist cements the provisional prosthesis.

The prosthetic phase continues for 6 months, for both healed and extraction sites. During this time, osseointegration has been obtained and soft tissues have healed.

After successful implant osseointegration is verified, the clinician takes an impression in the conventional way and sends it to the laboratory. After the final prosthesis is cemented, the occlusion is adjusted.



▲ **Fig 11-2e** Treatment option to rehabilitate the anterior maxilla when a cemented prosthesis is preferred and the principal determinant of treatment is the physical comfort of the patient. The sequence of steps is indicated in red. With this option, the final prosthesis is cemented.

Advantages

- The comfort of the patient is respected. The patient only has to sit through the surgery in the dental chair. Because the laboratory constructs the prosthesis, 1 or 2 hours of chair time is eliminated.
- The prosthodontist is sparing the tedious fabrication of the restoration at chairside.
- Because chair time is reduced, the fee paid by the patient can also be reduced.
- The cemented prosthesis conforms to the classic crown and bridge concept.
- The cemented prosthesis can be used effectively when implant access paths are divergent.
- Cast metal reinforcement can be incorporated in the prosthesis.
- With a metal framework, the provisional prosthesis is more resistant to fracture. It is reliable for a longer period than acrylic resin dentures, even those reinforced with a cast metal bar.

Disadvantages

- The patient is deprived of a restoration for 1 or 2 days following surgery.
- If the wax bite is inaccurate, the entire prosthetic phase may have to be repeated.
- Excess cement can be trapped in the gingiva.
- The prosthesis may debond.
- When a metal frame is used, the cost of the provisional prosthesis is increased.
- The risk of implant failure is not entirely eliminated by the use of the more costly metal framework.

Treatment tip:

- When a cemented prosthesis is preferred, this option is the most suitable.
- Prostheses of three units or greater should be designed with a cast metal reinforcement.
- When a cast metal framework is indicated, the prosthodontist should select a laboratory that is fully experienced in this technique.

Treatment option 5

Cemented provisional prosthesis placed within 24 to 48 hours after surgery; the final abutments and the prosthesis are prepared in the laboratory.

This option (Fig 11-2f) is chosen when:

- A cemented prosthesis is preferred over a screw-retained prosthesis.
- The physical comfort of the patient is the principal determinant of treatment.
- It is desirable, for whatever reason, to have the laboratory make the prosthesis.
- It is desirable to incorporate cast metal reinforcement in the prosthesis.

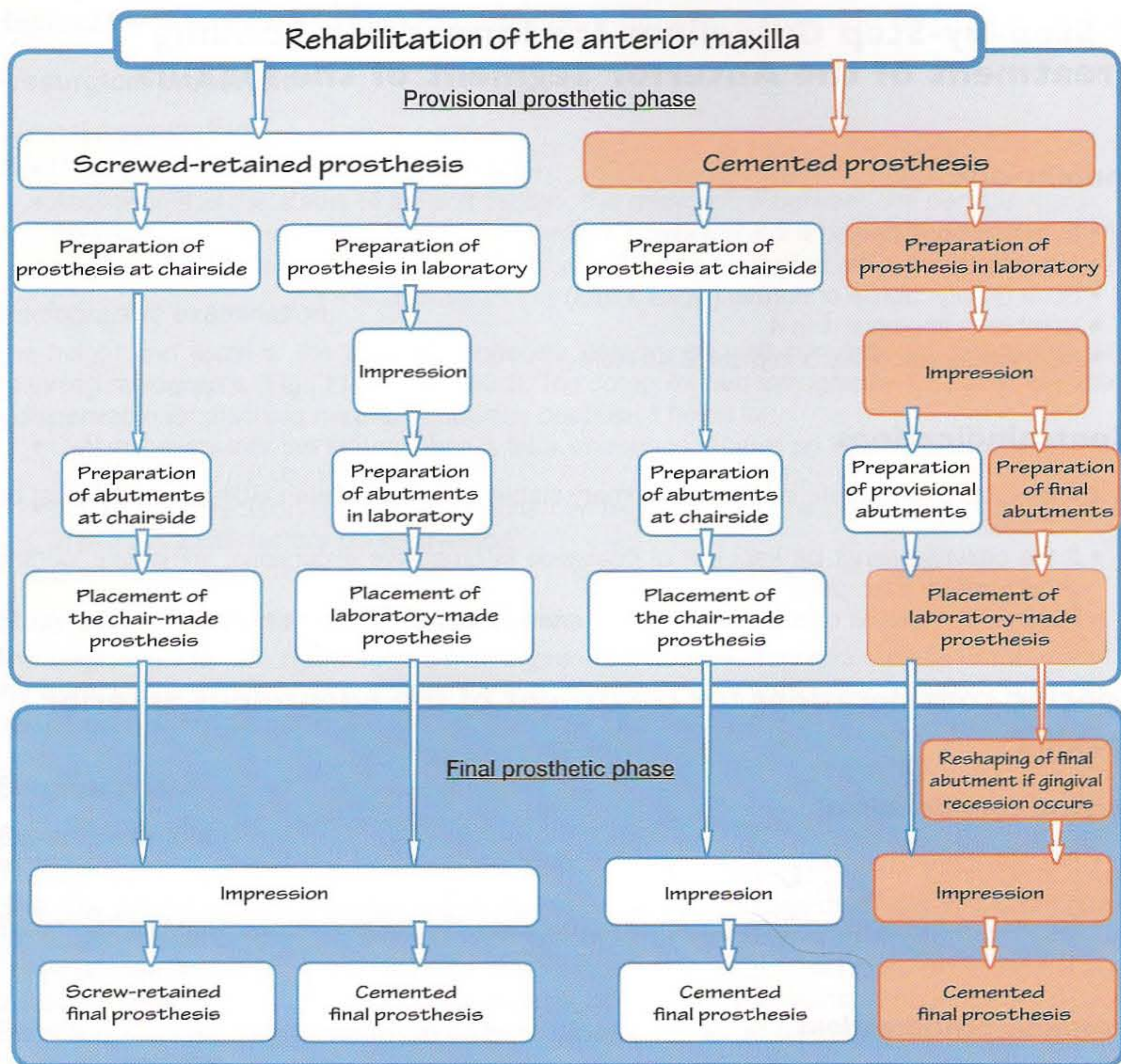
The laboratory constructs every element of the prosthesis, including the titanium or zirconia final abutments; these abutments will not be removed after placement, at any stage of treatment. The patient is treated in two distinct sessions and receives the fixed provisional prosthesis within 24 to 48 hours after surgery.

The prosthetic phase continues for 6 months, for both healed and extraction sites. During this time, osseointegration has been obtained and soft tissues have healed.

After successful implant osseointegration is verified, the clinician reshapes the final abutment if any gingival recession has taken place. An impression is taken in the conventional way and sent to the laboratory for fabrication of the final prosthesis. When the prosthesis is completed, it is cemented and the occlusion is adjusted.

Advantages

- This option combines all the elements for constructing a prosthesis with the best esthetic result, especially if the periodontal biotype of the patient is thin.
- The laboratory is able to fabricate more accurate abutments and provisional prostheses.
- The cemented prosthesis most closely conforms to the classic crown and bridge concept.
- A cast metal frame can be incorporated in the prosthesis.
- The physical comfort of the patient is respected. The patient only has to endure surgery and avoids 1 to 2 hours of prosthetic treatment in the chair.
- The prosthodontist is spared the tedious fabrication of the restoration at chairside.
- Because chair time is reduced, the fee also can be reduced.
- With a metal framework, the provisional prosthesis is more resistant to fracture. It is reliable for a longer period than acrylic resin dentures, even those reinforced with a cast metal bar.



▲ **Fig 11-2f** Treatment option to rehabilitate the anterior maxilla when a cemented prosthesis is preferred and the principal determinant of treatment is good esthetics. The sequence of steps is indicated in red. With this option, the final prosthesis is cemented.

Disadvantages

- The patient is deprived of a restoration for 1 or 2 days following surgery.
- If the wax bite is inaccurate, the entire prosthetic phase may have to be repeated.
- The prosthesis may debond.
- When a metal framework is used, the cost of the provisional prosthesis is increased.
- The risk of implant failure is not entirely eliminated by the use of the more costly metal framework.

Treatment tip:

- This protocol is the one that must be chosen when esthetic considerations are important, especially when the patient has a thin periodontal biotype.
- Metal reinforcement should be incorporated in prostheses of three or more units.
- When a cast metal framework is indicated, the clinician should select a laboratory that is fully experienced in this technique.

▼ Step-by-Step Guidelines for Immediate-Loading Treatment of the Anterior Segment of the Maxilla

Indications

- Available bone height at implant site: ≥ 11.5 mm
- Available bone width at implant site: ≥ 6 mm
- Bone quality: dense or normal (types 1 to 3)
- Number of implants: 1 to 4
- Insertion torque of each implant: ≥ 45 Ncm

Contraindications

- If implants demonstrate inadequate primary stability, the immediate-loading protocol must be discontinued.
- If the crowns cannot be kept out of occlusion in protrusive excursions, immediate loading should not be attempted.
- Patients who exhibit bruxism are not good candidates for immediate loading.

Specific considerations for treatment of the edentulous anterior maxilla

Surgical considerations

- Precise three-dimensional (3D) implant positioning is crucial when esthetic considerations prevail (see chapter 5).
- For prospective screw-retained crowns or prostheses, the surgeon must ensure that the implant axis will be compatible with a palatal screw access path (options 1 and 2).

Prosthetic considerations

- The prosthesis must be kept out of occlusion.
- The provisional prosthesis must be designed in a way that will provide guidance and encourage maturation of the soft tissues (see chapter 6).
- It may be difficult to accurately predict the soft tissue reaction in an effort to obtain satisfactory esthetics.
- If the restoration is cemented, the clinician must spend time in the scrupulous removal of excess cement (options 3 to 5).

Surgical phase: Case reports

The treatment options and the prosthetic phase for the anterior maxilla that is edentulous or is becoming edentulous are identical; only the surgical phase differs. Therefore, a variety of different surgical situations will be presented, but only one case will be described for each prosthetic option.

First, restoration of a single crown in an extraction site will be discussed. This type of indication is best suited for immediate loading. In addition, it provides an ideal stage for explaining the principles of implant placement in the maxillary anterior region.

Replacement of a single tooth in a maxillary anterior extraction site

Presurgical preparation

Clinical examination

- Determination of the smile line (Fig 11-3a)
- Assessment of the status of the soft tissues, the relationship between the cervical margin of the tooth to be restored and its adjacent teeth or crowns, and the presence and quality of the papillae (Fig 11-3b)

Radiographic examination

The height and width of the available bone are determined with conventional, panoramic, and scanning radiographs (Figs 11-3c and 11-3d). The computerized tomography (CT) scan is virtually indispensable for planning maxillary implants, because it helps to:

- Determine whether the buccal plate is thick enough to receive an implant that will perform in an esthetically satisfactory manner.
- Locate with precision concavities in bone that might threaten the continuous coverage of an implant in a satisfactory bone envelope.
- Confirm the available bone height that was revealed in the periapical radiograph.

Study casts: Preparation of the surgical guide

The surgical guide, which is made from an impression, does not reproduce the axial inclination of the extracted tooth (Fig 11-3e). Instead it will guide implant placement into a position with a more palatal inclination than that of the natural tooth (see Figs 5-23 and 5-24).

Surgical phase

Extraction of tooth

If necessary, tartar should be removed from teeth in the affected region before the surgical procedure. The patient should be treated with antibiotics as early as 3 days or as late as 2 hours before the surgery, depending on the reason for extraction, either infectious or traumatic.

In this case, the tooth, which had a Richmond crown (Fig 11-3c), had to be extracted because of a subgingival root fracture. In this instance, antibiotic therapy was started 2 hours before surgery. Extraction was carried out carefully in an atraumatic way to avoid damaging bone, especially the critical buccal plate.

Placement of implant

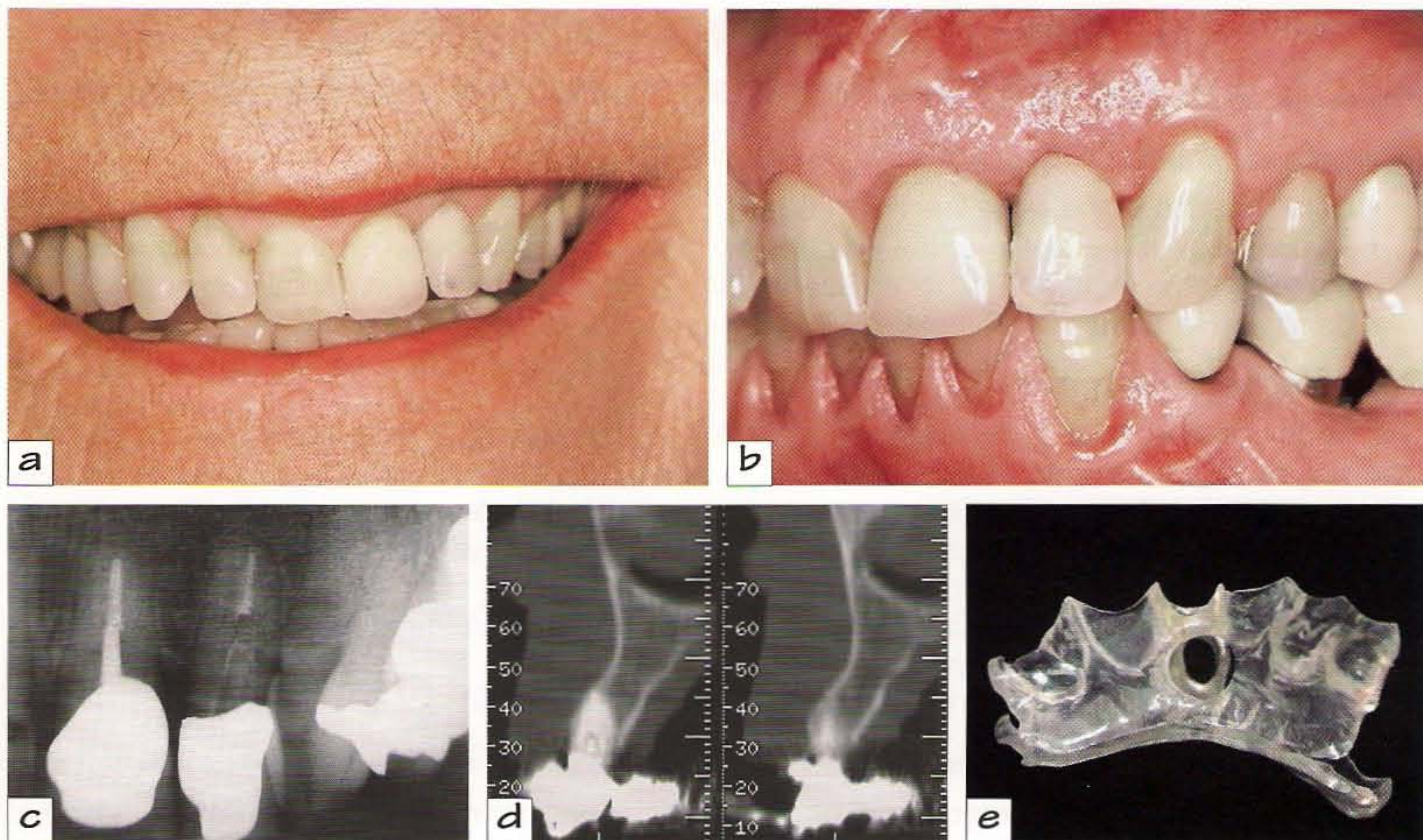
Analysis of osseous and gingival landmarks. Figure 11-3b provides a full picture of the gingival structures. The tooth to be replaced had a crown for many years. The periodontal biotype of the patient was thick. The gingiva, especially in the region where the implant was planned, exhibited varying heights of attachment around the cervical parts of teeth. The gingival papillae did not completely fill the embrasure spaces.

Esthetically, the aim was to maintain the presurgical positions of the gingival margin and the papillae. Because the implant was surrounded by natural teeth, the papillae would receive support from the adjacent teeth.

Access to the implant site was obtained without a flap to limit changes in the gingival margin. A 2-mm space was to be left between the edge of the implant and the buccal plate.

Selection of implant design.

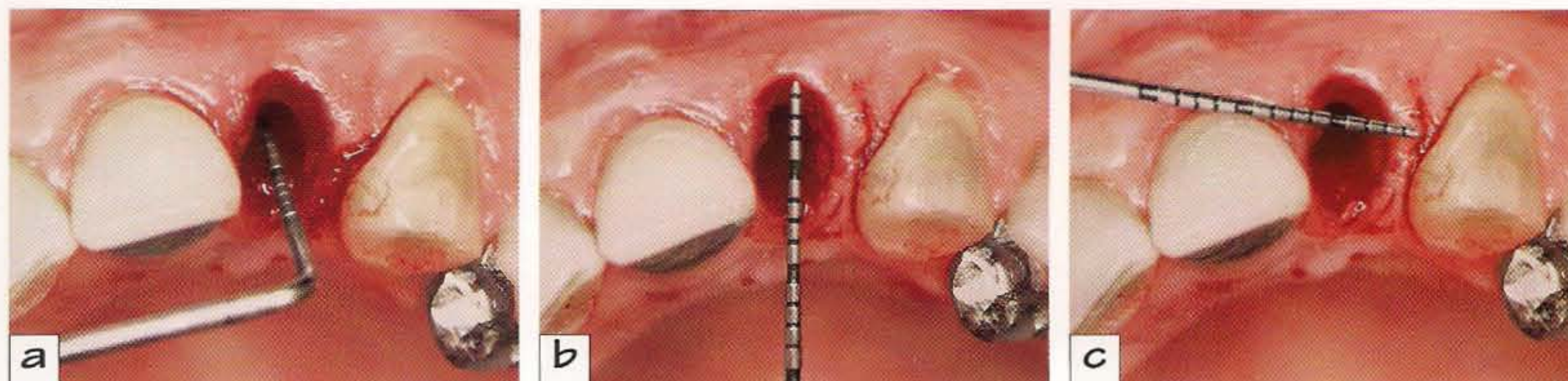
1. *Implant type.* For this type of maxillary anterior site, conical implants or implants designed with platform switching would provide the best primary stability and the best prospects for a good esthetic prognosis.



▲ **Fig 11-3** Presurgical examination. (a) Determination of the smile line. The smile line is high, showing the necks of the teeth and the gingival margin; esthetic considerations will prevail. (b) Determination of the soft tissue relationship. The periodontal biotype is thick. The necks of the teeth form an irregular line that does not adhere to the classic concept of gingival esthetics; this will provide some flexibility for obtaining a satisfactory esthetic result. Gingival quality is average and visible interproximal spaces are not filled with a well-fitting papilla. Management of the papilla should not be very demanding. (c) Periapical radiograph revealing the available bone height beyond the apex. (d) CT scan (oblique section). The thickness of the buccal plate is measurable. Its extent throughout is sufficient to receive an implant. This view would also detect the presence of any unexpected osseous convexities. In this case, it confirms the available bone height. (e) Surgical guide. It is restrictive and defines precisely the mesiodistal and buccolingual axes for drilling.

2. *Implant length and diameter.* Direct measurements of the socket of the extracted tooth revealed that the alveolus was 11.0 mm deep (Fig 11-4a), 7.0 mm wide buccolingually (Fig 11-4b), and 4.5 mm wide mesiodistally (Fig 11-4c). A conical 4.0-mm-diameter Osseotite NT implant was the best choice for replacing this maxillary lateral incisor. A larger implant diameter would have infringed on the alveolar dimensions and made it difficult to create a harmonious emergence profile.

The radiographs revealed that the available bone height was sufficient for accommodating a 15.0-mm-long implant. Drilling was performed 4.0 mm beyond the apex to increase primary stability.



▲ **Fig 11-4** Measurement of the alveolar dimensions. (a) Measurement of the alveolar depth. The depth is 11 mm; a 15-mm-long implant is planned in order to go 3 to 4 mm beyond the apex of the socket. (b) Measurement of the buccolingual width, which is 7.0 mm. (c) Measurement of the mesiodistal width. It is 4.5 mm, as shown on the probe.

Preparation of osseous site. Access to the alveolus was direct, without a flap. The “blind” approach was performed with a graduated implant driver, taking into account a gingival height of 3.0 mm.

Drilling sequence. The conventional drilling pattern was followed, without tapping.

3D positioning.

Reminder:

The positioning of an implant in a maxillary anterior extraction site was discussed in detail in chapter 5.

1. *Mesiodistal axis.* This axis is the same as the axis of the crown it is going to support. It is indicated on the surgical guide (Fig 11-5a).
2. *Buccopalatal axis.* The buccopalatal axis is not the same as that of the extracted tooth. It will deviate from the original inclination by about 5 degrees in a palatal direction, in order to leave at least 2.0 mm between the buccal edge of the implant and the edge of the buccal plate. This inclination is incorporated in the surgical guide (Fig 11-5b).

With a round bur, a notch is prepared in the apical third of the palatal wall (see Fig 11-5b). The pilot drill extends from this notch beyond the apex of the alveolus. Figures 11-5c and 11-5d show how this pilot bur establishes the implant axis.

3. *Coronoapical axis.* In this case, the implant was to be placed about 1 mm subcrestally. The 3.0- and 4.0-mm-diameter burs were used to prepare the osteotomy site to the depth that would accommodate this position (Figs 11-5b, 11-5e, and 11-5f).

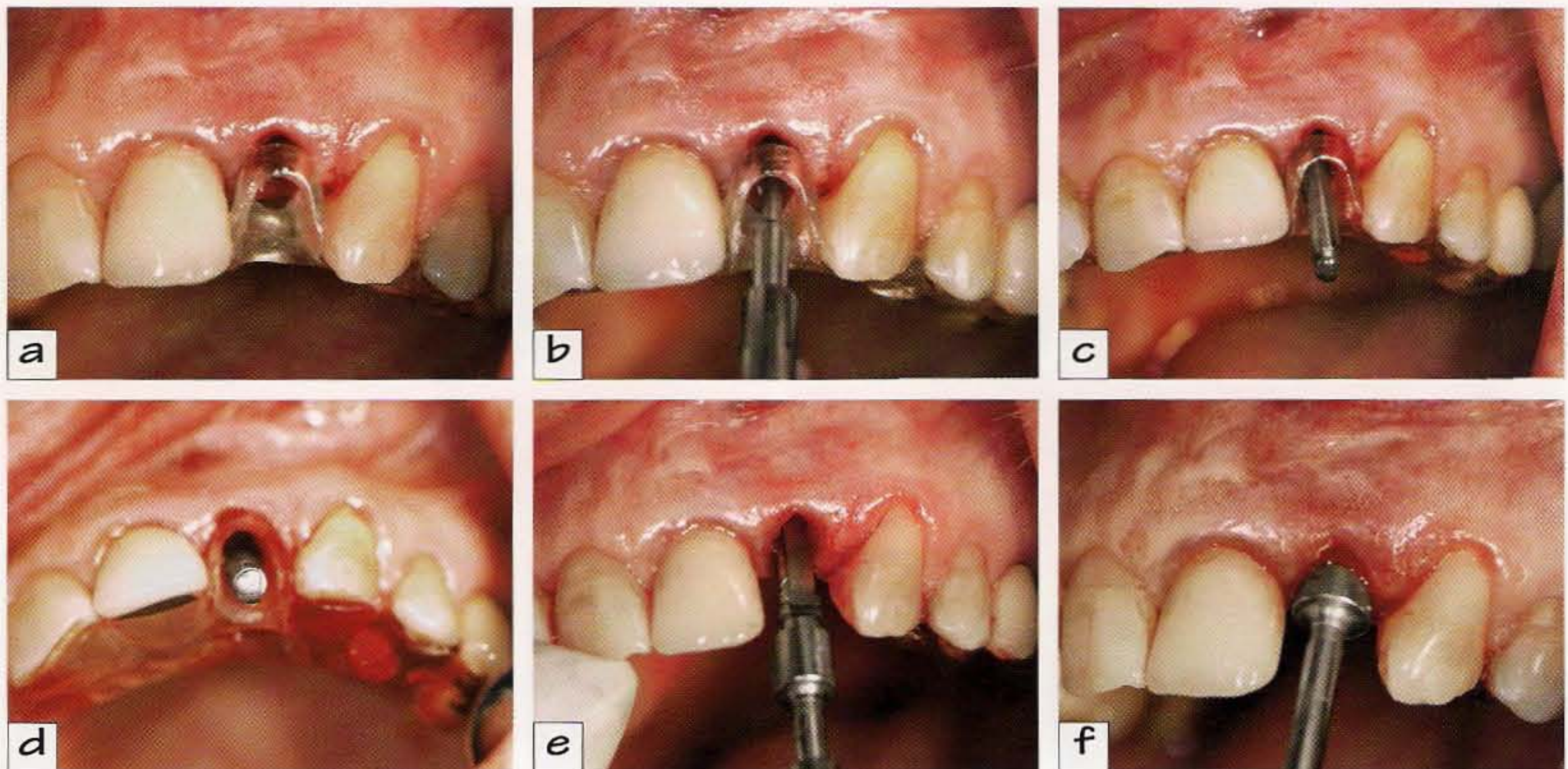
The surgeon must add 3.5 mm to this distance from the bone level mark to accommodate the gingival height (see Fig 11-5f).

After the site was prepared and measured, the implant was placed (Fig 11-6a). The implant carrier indicated that the implant neck was situated 3.5 mm below the marginal gingiva (Fig 11-6b).

Primary stability. The motor, set at 40 Ncm, stalls before the implant is completely seated in its bed. At a torque setting of 50 Ncm, implant seating is completed in the alveolus (see Fig 11-6b).

Use of bone profiler. With the implant carrier removed, the neck of the implant is visible in the alveolus (Fig 11-6c). The surgeon uses the bone profiler to ensure that the healing abutment as well as the provisional abutment are fully seated.

The bone profiler guide is screwed into the implant and emerges through the gingiva (Fig 11-7a). At this time, the clinician can check if the axis of the implant conforms to that of the surgical



▲ **Fig 11-5** Drilling of the implant site in the alveolus. (a) Placement of the surgical guide, which indicates the mesiodistal angulation. (b) Drilling in the site with a round bur. The palatal inclination engages the palatal alveolar wall in its apical third. (c) Orientation of the round bur (buccal view). (d) Orientation of the round bur (occlusal view). Note its palatal inclination. (e) using of the first drill in the alveolus. Its palatal orientation is the same as that of the round bur. (f) Use of the final drill. Note its palatal orientation and the depth to which the drill has been inserted. The mark noting the bone level is not visible; an allowance of 3.5 mm was added to the drill depth to account for the gingival height and ensure subcrestal placement of the implant.

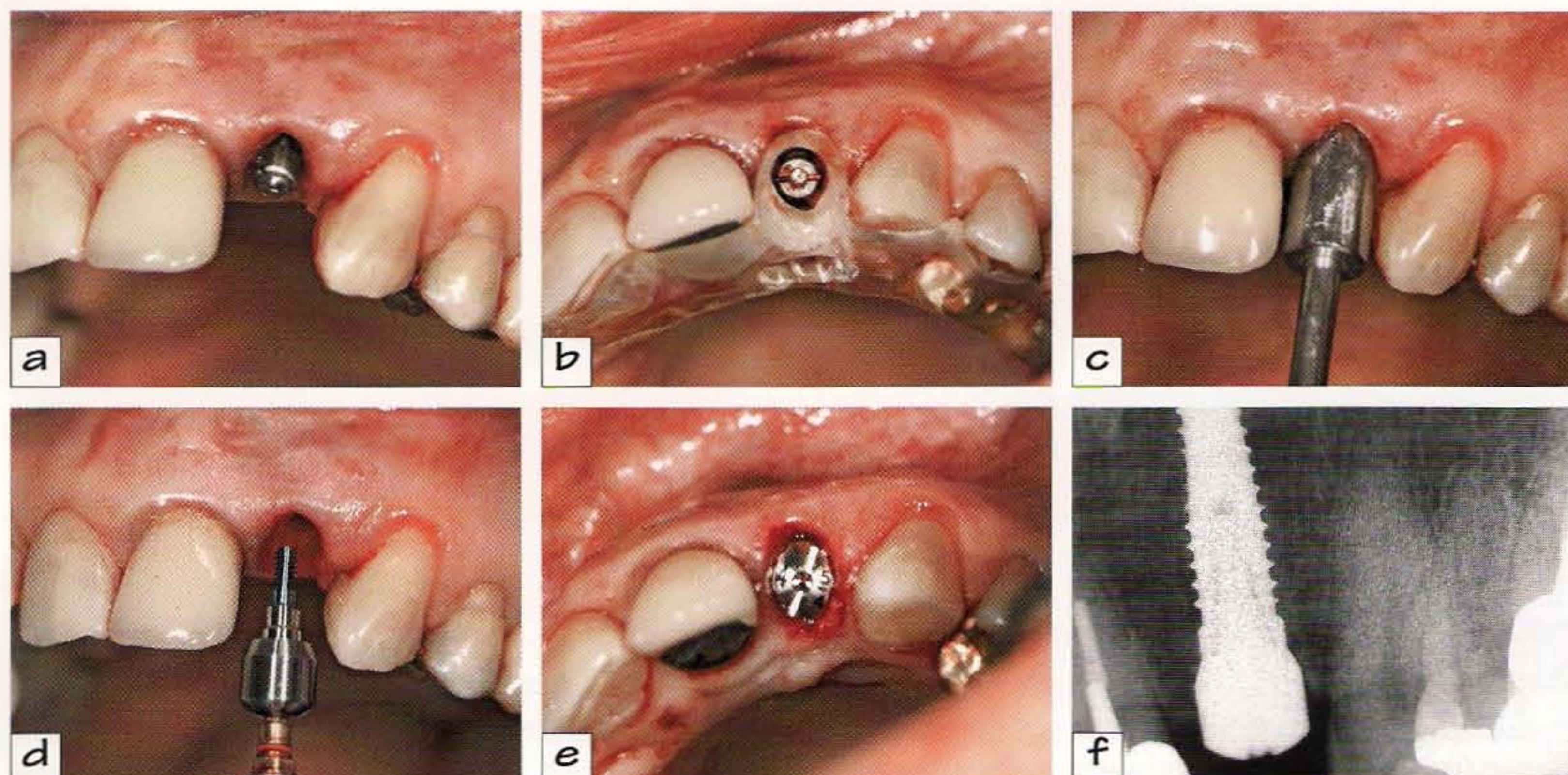


▲ **Fig 11-6** Positioning of the implant. (a) Implant in the course of placement. Note the implant carrier (in gold) with its gradations of 1.0-mm each. (b) Coronoapical position of the seated implant. It is slightly subcrestal, as shown by the carrier reading of 3.5 mm below the gingiva. (c) Implant after removal of the implant carrier. The opening to the alveolus seems to be larger than the underlying implant.

guide (Fig 11-7b). The bone profiler is used to remove any osseous obstacles that may interfere with complete seating of the abutments (Fig 11-7c).

Placement of healing abutment. The healing cap is screwed in place, emerging somewhat above the alveolus of the extracted tooth (Figs 11-7d and 11-7e). This step marks the end of the surgical phase of treatment. The patient then moves from the surgical site to the prosthetic site.

Even if the same practitioner is performing both the surgical and prosthetic phases, the healing abutment is placed when the postoperative control radiograph is taken, to avoid collapse of the soft tissue.



▲ **Fig 11-7** Steps following implant placement. (a) Placement of the profiler guide in the alveolus. (b) Confirmation of the orientation of the implant, which should coincide with the center of the guide. This implant is precisely where it should be. (c) Insertion of the bone profiler. (d) Placement of the healing abutment, which is 3 mm high. (e) Healing abutment in place. No suture is needed. At this stage and in this condition, the patient proceeds from the surgical to the prosthetic phase. (f) Control radiograph. Note the subcrestal position of the implant and the healing abutment.

Suturing. No sutures are needed because the abutment is immediately placed on the implant to support the soft tissues.

Control radiograph. A radiograph is taken to ensure that the implant has been placed in an adequate subcrestal position (Fig 11-7f).

Transition from surgical treatment site to prosthetic treatment site. The transition from the surgical site to the prosthetic site should be planned in advance, to avoid any misunderstandings and to ensure that the patient experiences a seamless transition from one specialist to the other.

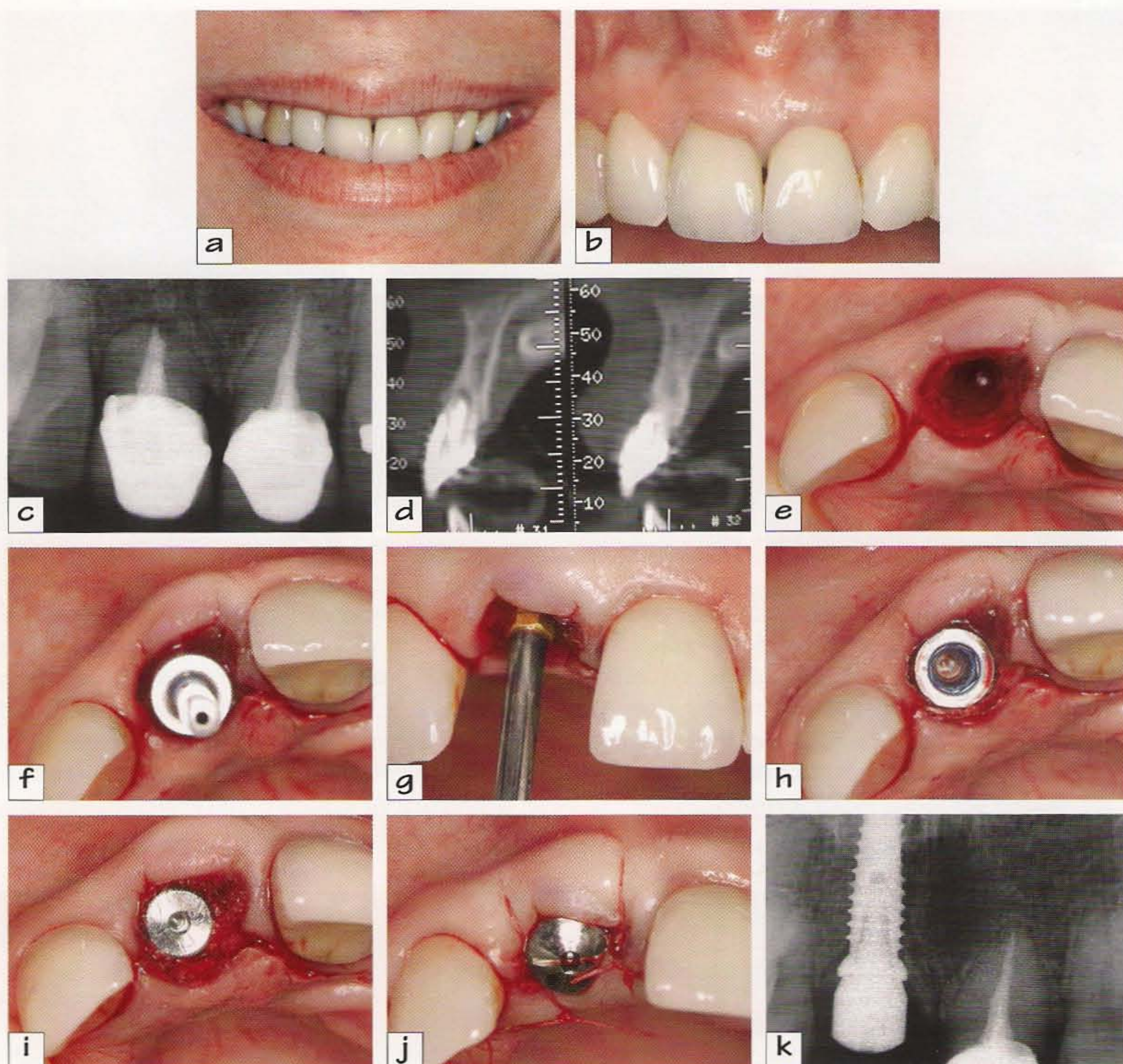
The prosthetic phase is discussed later in the chapter, after the surgical approaches to other types of maxillary anterior tooth loss are described.

Treatment variant in a single-tooth extraction site

The clinical (Figs 11-8a and 11-8b) and radiographic (Fig 11-8c) examinations are identical to those performed for the previous case. The specific characteristics of this case are:

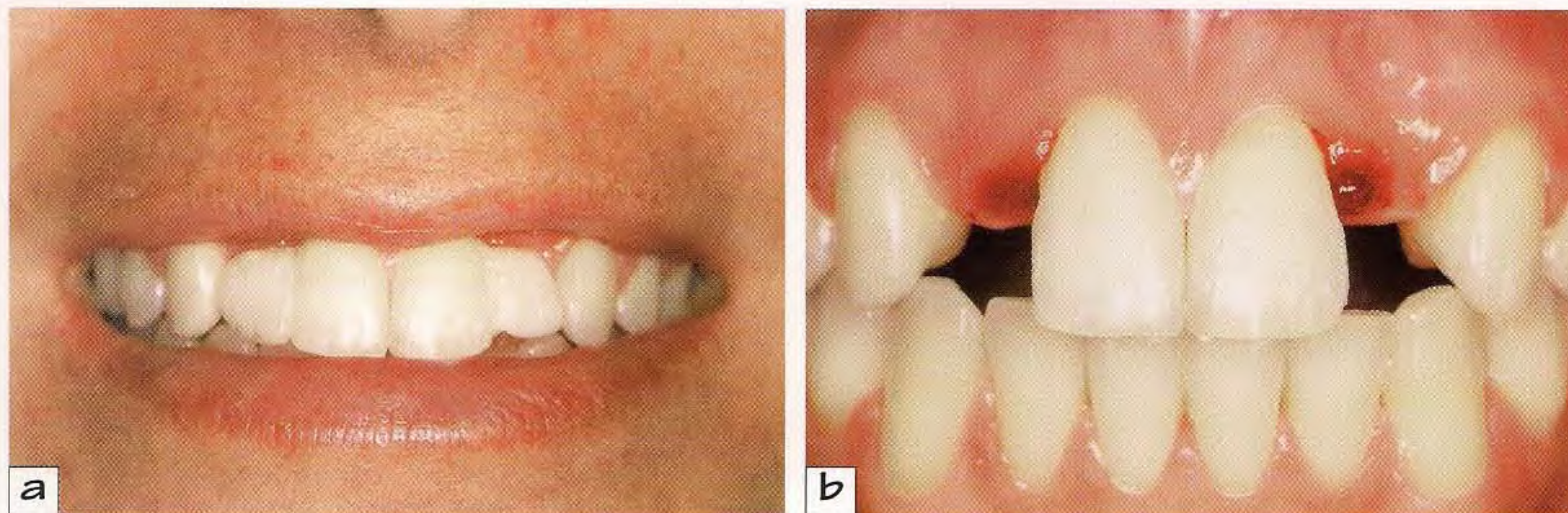
- The presence of a substantial anterior palatal canal that was detected on the CT scan (Fig 11-8d).
- The need to reflect a flap at the extraction site in order to obtain good surgical visualization (Fig 11-8e).
- The need to fill the gap in the alveolus with a bone substitute material because the implant does not completely fill the extraction socket.

The buccolingual axis was inclined palatally (Fig 11-8f) to leave a space of at least 2.0 mm between the implant edge and the external border of the buccal plate. A Prevail platform-switching implant was seated 3.5 mm below the marginal gingiva (Figs 11-8g and 11-8h).



▲ **Fig 11-8** Surgical steps in the replacement of a single tooth in an extraction site (variant). (a) Patient's smile line. (b) Maxillary right central incisor to be extracted. (c) Preoperative periapical radiograph. (d) CT scan (oblique view) of the maxillary right central incisor: The palatal canal is large. (e) Palatal incision that helps the surgeon visualize any anatomic obstacles. (f) Drilling at a palatal inclination. (g) Vertical position of the implant. The gingival margin is 3.5 mm above the implant neck. (h) Clinical view after the implant has been seated. There is a substantial gap between the implant and the mesial wall of the alveolus. (i) Filling of the gap. Note the protective screw on the implant. (j) Sutures, placed mesial and distal to the healing abutment. (k) Control radiograph with the healing abutment in place. Platform switching was used.

The alveolus was wider mesiodistally than the implant (see Fig 11-8h). Therefore, after the implant was protected with a cover screw (Fig 11-8i), the gap was filled to a depth of about 2.0 mm from the occlusal limit with bone chips harvested from drilling beyond the apex. A healing abutment was placed and the palatal incision was sutured (Fig 11-8j). The postoperative control radiograph revealed the outline of the platform switching (Fig 11-8k).



▲ **Fig 11-9** Presurgical examination. (a) Determination of the smile line. The smile line is high and discloses the necks of the anterior teeth. The restorations will have to fulfill high esthetic demands. (b) Determination of the esthetic requirements of the restorations with regard to soft tissues. The periodontal biotype is thick, and the line connecting the necks of her teeth does not conform to ideal esthetic criteria. Because bone tissue is abundant, the prosthodontist will have a certain amount of flexibility in management of the papillae.

Replacement of a single tooth in a maxillary anterior healed site

Presurgical preparation

A young woman sought the replacement of two congenitally absent maxillary lateral incisors. Orthodontic treatment had reopened the spaces, which had been partially closed by mesial drifting of teeth distal to the sites. Subsequently, two immediately loaded implants were planned to rehabilitate her anterior maxilla.

Clinical examination

- Determination of the smile line (Fig 11-9a)
- Assessment of the soft tissue status, the future relationship of the cervical margin of the proposed crowns and the adjacent teeth, and the presence and quality of the papillae (Fig 11-9b)

Radiographic examination

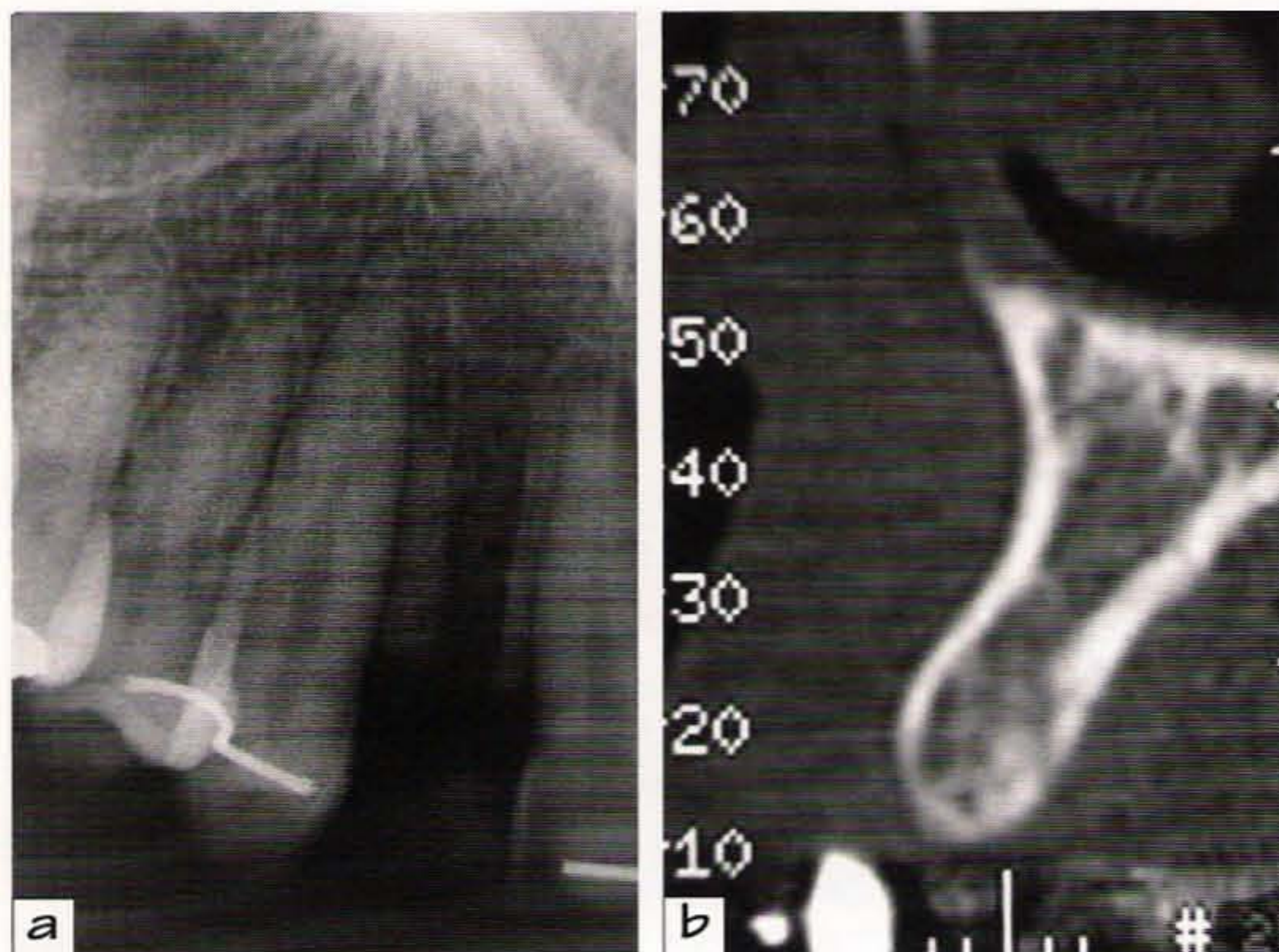
The height and width of the ridge are determined with the aid of a periapical radiograph (Fig 11-10a) and a CT scan (Fig 11-10b).

The CT scan is indispensable because it:

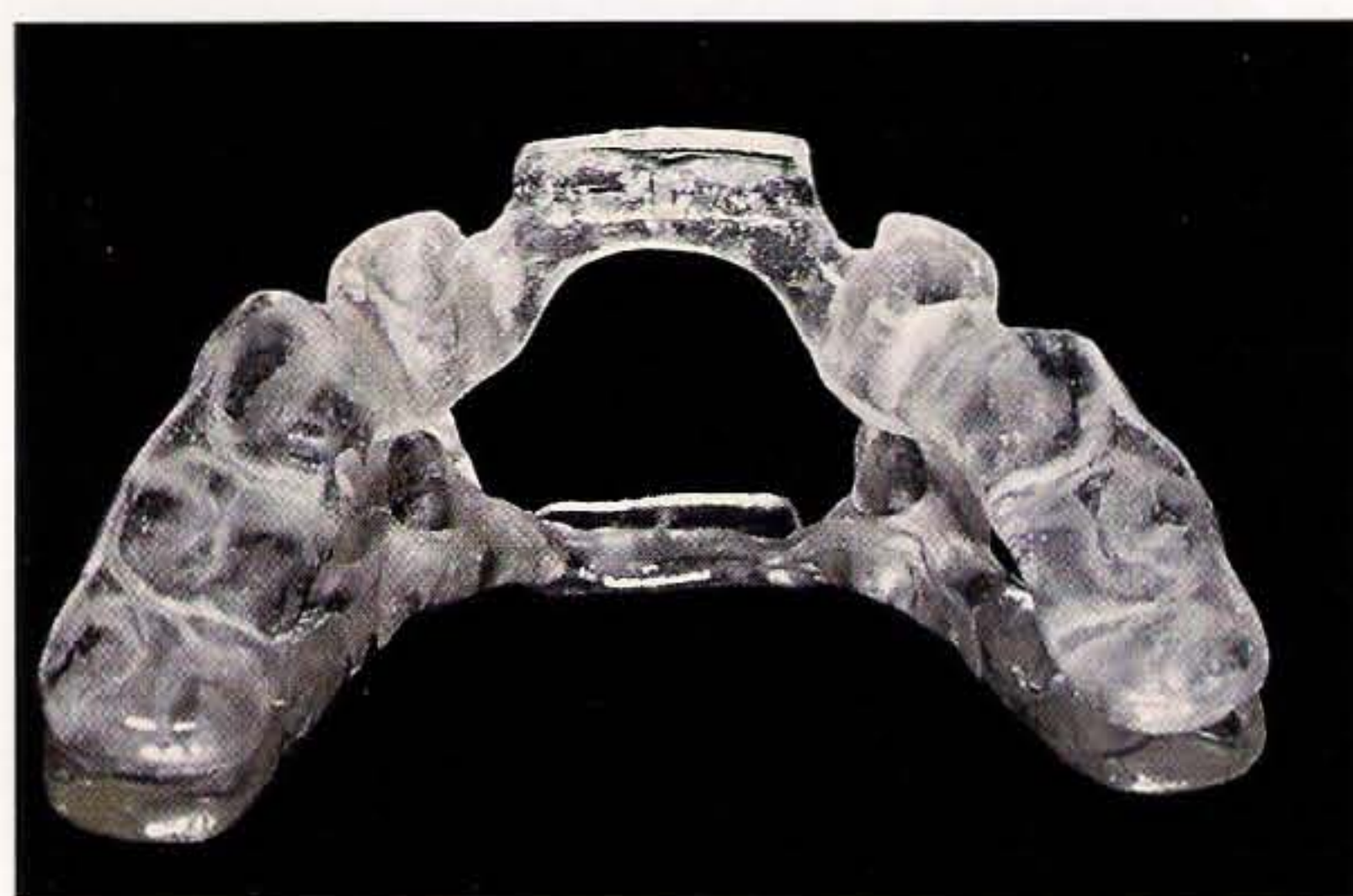
- Permits assessment of the buccal plate to determine if it is large enough to support an implant. The thickness of the buccal plate is a factor in the esthetic success of the restoration.
- Allows precise visualization of any concavities that would weaken the bony support needed for maintenance of an implant.
- Confirms the bone height estimated from the periapical radiograph.

Study casts: Preparation of a surgical guide

The surgical guide is restrictive and provides the surgeon with precise mesiodistal and buccopalatal axes for implant bed preparation (Fig 11-11). The orientation of the buccopalatal axis should take into account the need to maintain a 2-mm distance between the implant edge and the border of the buccal plate.



◀ **Fig 11-10** Radiographs used to assess the extent of the available osseous envelope. (a) Periapical radiograph revealing the available bone height beyond the apex of the alveolus. (b) CT scan (oblique section). The extent of the buccal plate is assessed. The scan would also reveal any unexpected bone concavities. This section indicates that the buccal plate is thick enough throughout its length to support an implant and confirms the available bone height suggested by the periapical radiograph.



◀ **Fig 11-11** Surgical guide. The guide is restrictive, determining precisely the mesiodistal and bucco-palatal axes of the implants.

Surgical phase

Placement of implant

Analysis of osseous and gingival landmarks. Assessment of the clinical situation and radiographs revealed that the patient's biotype was thick and the underlying bone was abundant.

The esthetic goal was to create restorations with papillae and gingival margins compatible with those of adjacent teeth. The implants were to be placed between healthy natural teeth whose periodontium would provide good support for the papillae.

Selection of implant design.

1. *Implant diameter and type.* For this maxillary location, narrow 3.4-mm conical implants were indicated. The platform-switching strategy could not be implemented because there was no narrower abutment.
2. *Implant length.* The radiographs demonstrated that enough bone was available to receive a 13.0-mm-long implant (see Figs 11-10a and 11-10b).

Preparation of osseous site. Despite the esthetic demand, a flap was raised to gain access to the implant site (Figs 11-12a and 11-12b). Actually, the abundance of hard tissue and the strong character of the soft tissues indicated that there was little risk of gingival recession and a

disappointing esthetic outcome. Nevertheless, releasing incisions were avoided for esthetic reasons, and the incision was made through the sulci of the adjacent teeth (see Fig 11-12b).

Drilling sequence. The drilling sequence follows the customary pattern without bone tapping (Figs 11-12c to 11-12e).

3D positioning.

Reminder:

Implant positioning in a maxillary anterior extraction site was discussed in detail in chapter 5.

1. *Mesiodistal axis.* The mesiodistal axis of the implant corresponds to the crown it is going to support. It is indicated by the surgical guide (see Fig 11-12c).
2. *Buccopalatal axis.* The emergence position should allow 2 mm between the rim of the buccal plate and the external implant edge. The vertical axis of the implant should emerge on the palatal surface of the crown. Its palatal inclination is given by the surgical guide.
3. *Coronoapical axis.* The implant neck should lie 2.0 mm below the cemento-enamel junctions of the adjacent teeth and should be subcrestal by more than 1.0 mm. Figure 11-12f shows the implant positioned so that the implant neck was level with the crest, in an unacceptable position. The implant was removed and replaced in its sterile packing while the site was redrilled apically to allow an appropriate 1.5 mm subcrestal positioning (Figs 11-12g and 11-12h).

Primary stability. The torque is first set at 40 Ncm, and the drill stalls before the implant is completely seated in the alveolus. When the operator resets the drill at a torque of 50 Ncm, the implant finishes its final seating into the socket (see Figs 11-12g and 11-12h).

Use of bone profiler. In this case, the implant carrier was removed, revealing that the implant neck was clearly subcrestal (see Fig 11-12h). After seating of the implant, the action of the bone profiler is required to ensure that the healing abutment or the provisional abutment will be completely seated on the implant. The bone profiler guide is screwed in place and the bone profiler is used to remove any bone spurs that could interfere with complete seating of the abutments (Figs 11-12i and 11-12j).

Placement of healing abutment. A healing cap is screwed in place before the control radiograph is taken (Fig 11-12k), even if a single clinician serves as both surgeon and prosthodontist.

Suturing. The gingiva around the abutment is sutured.

Control radiograph. A radiograph is taken to verify the correct subcrestal placement of the implant (Fig 11-12l).

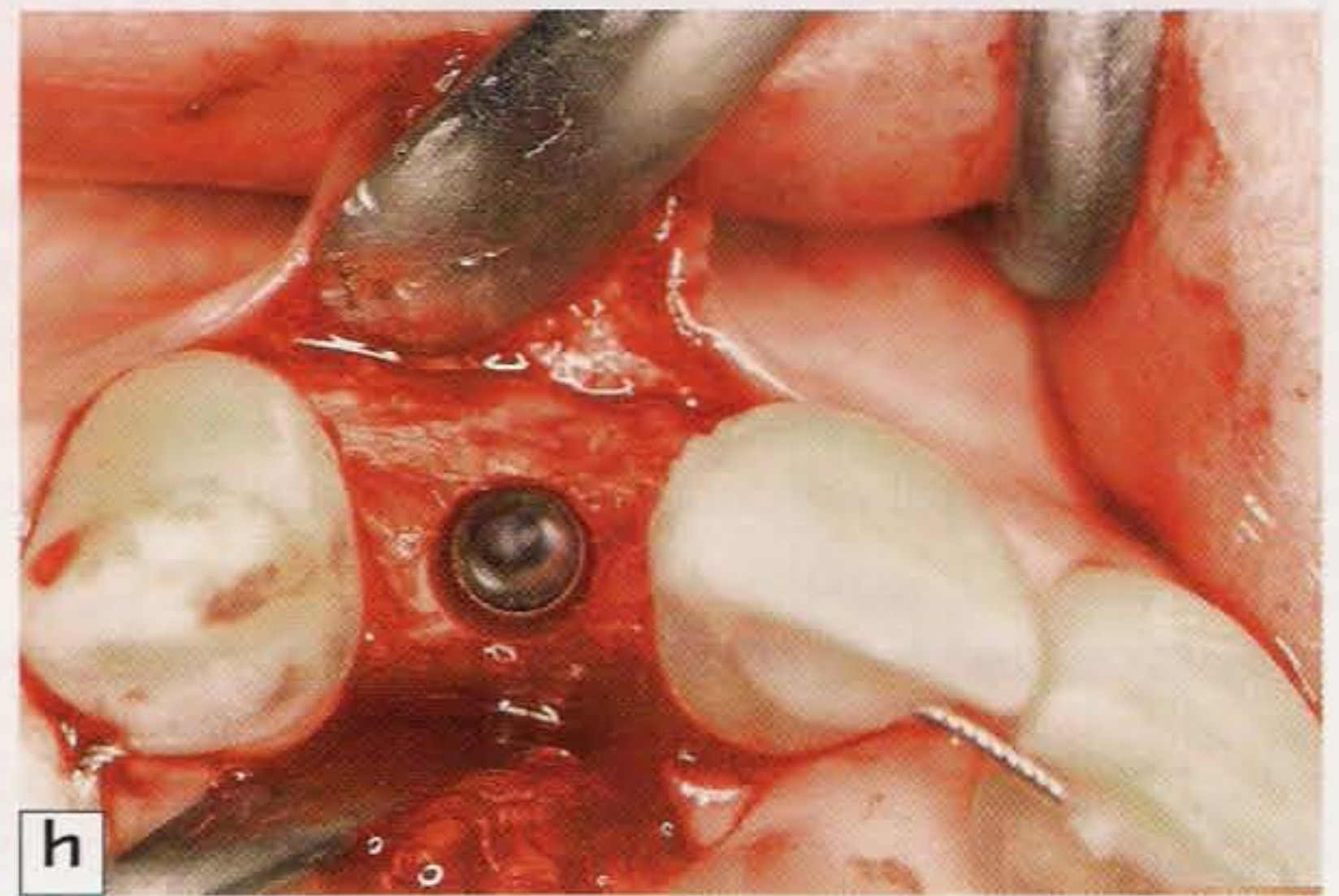
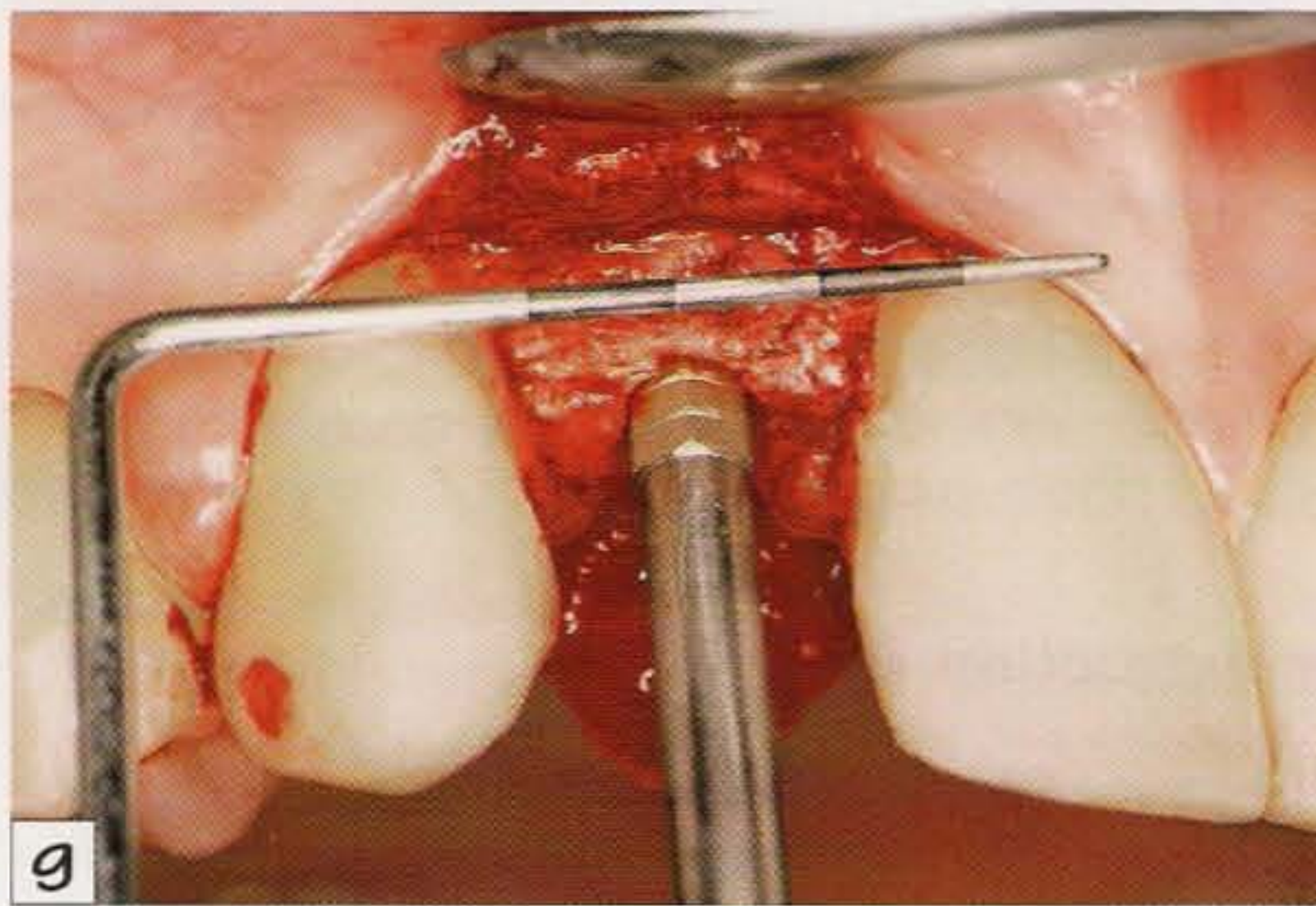
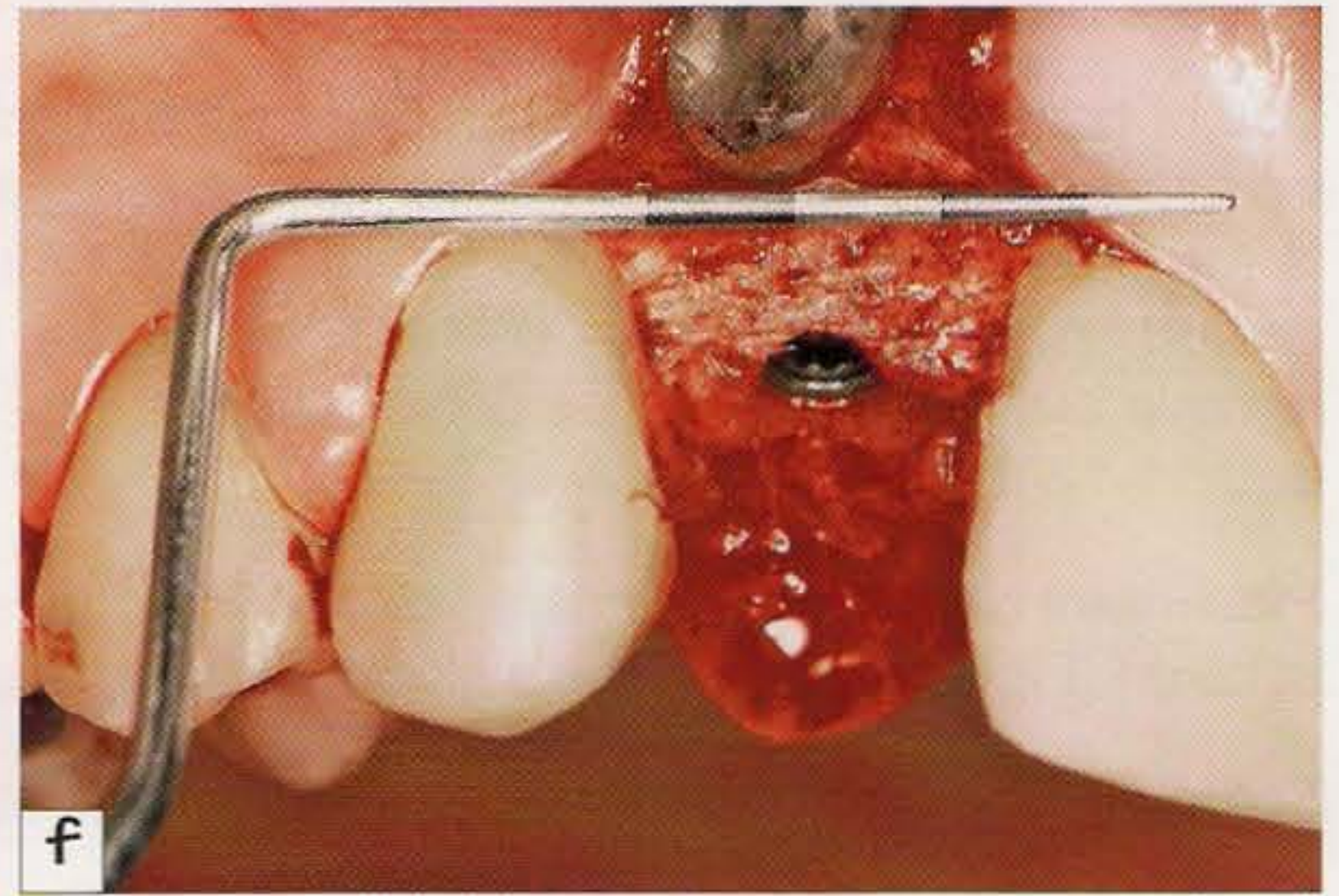
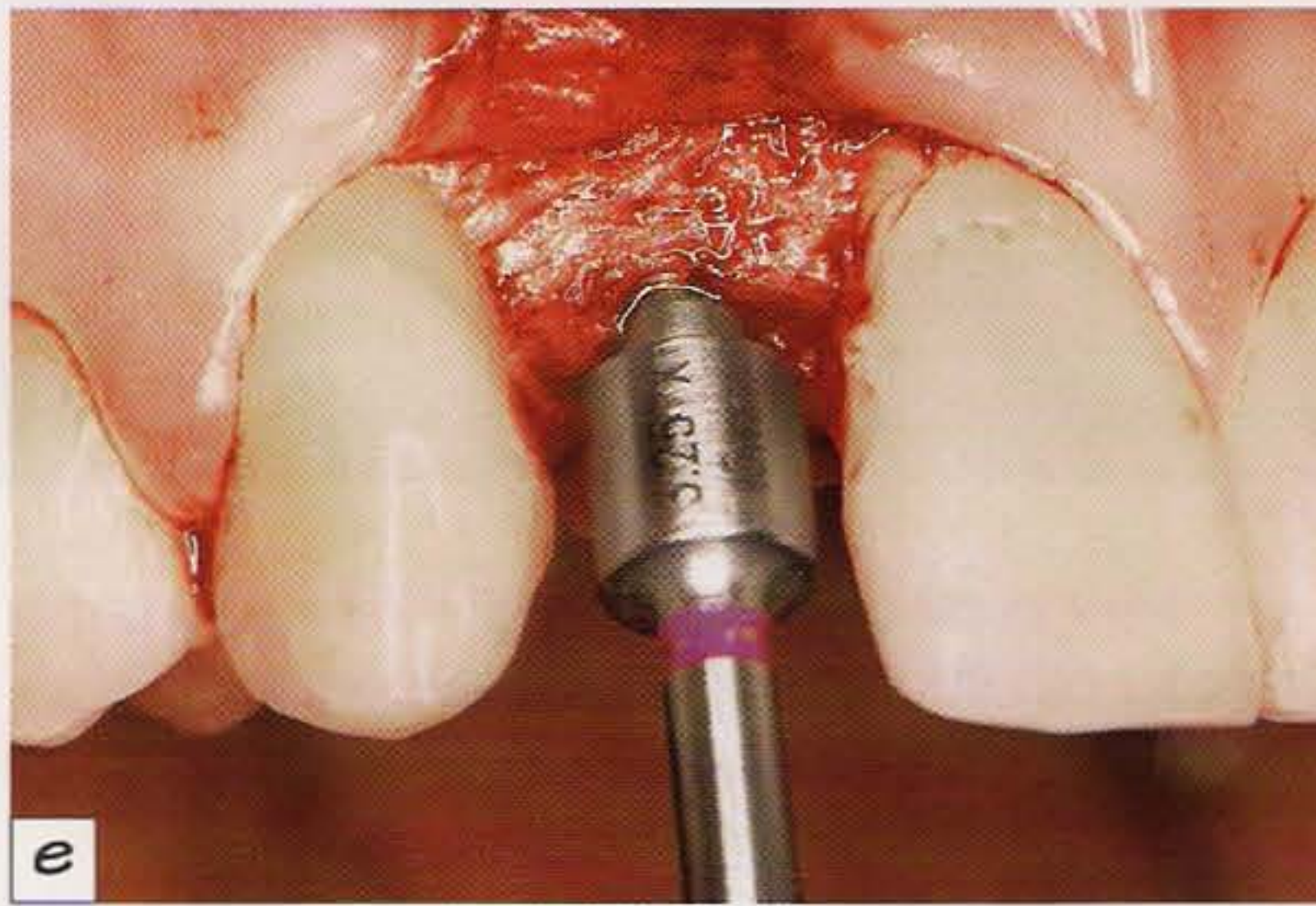
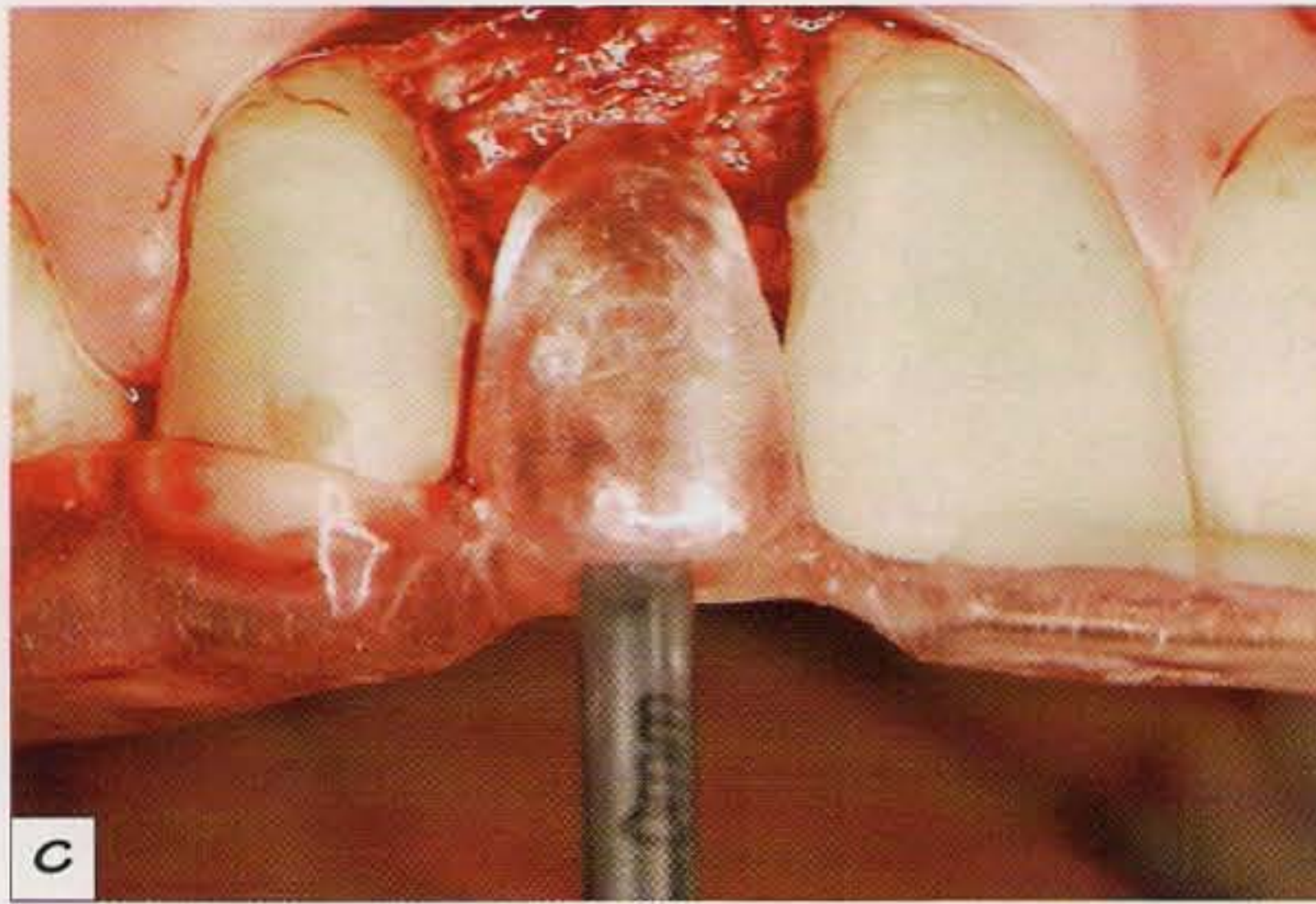
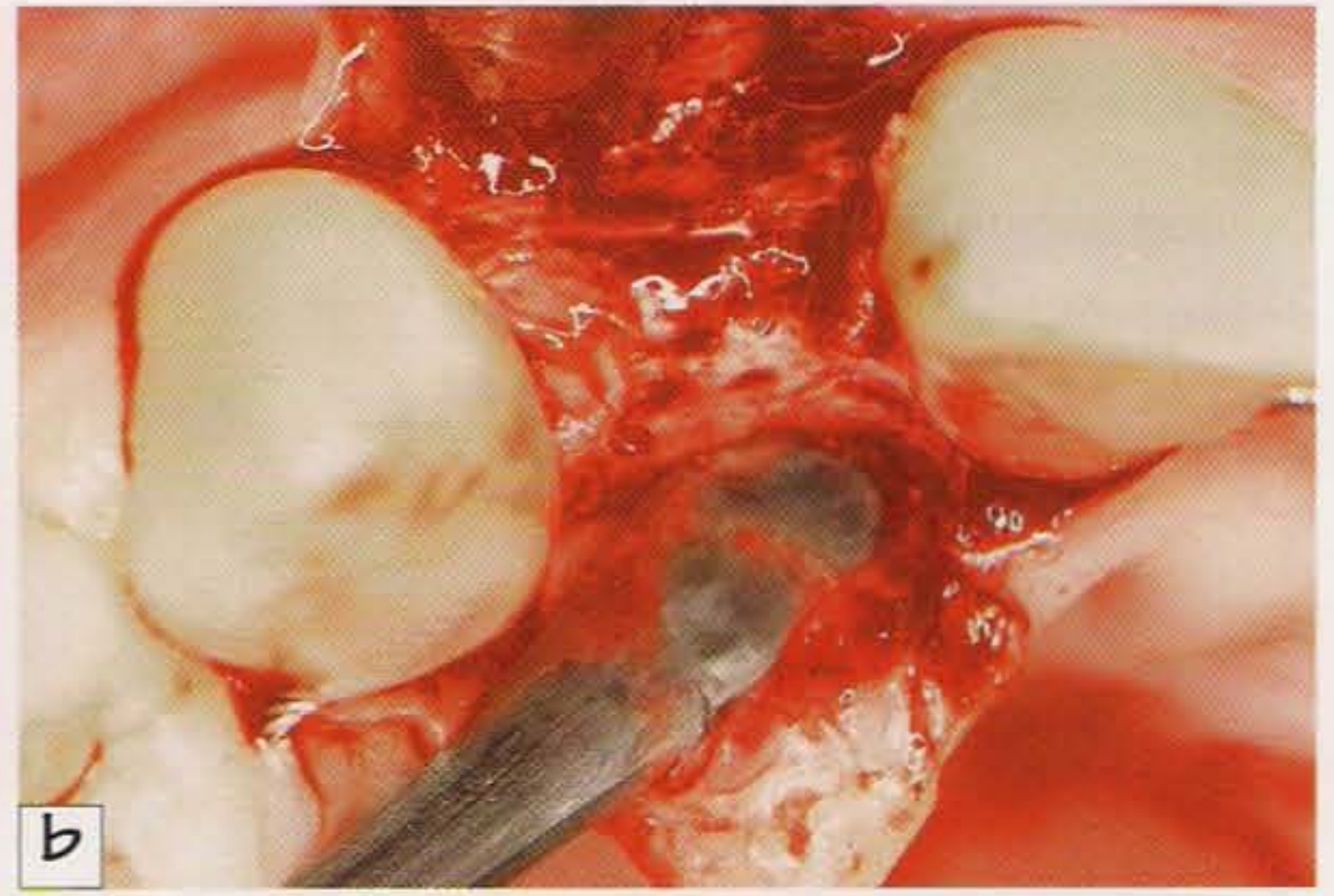
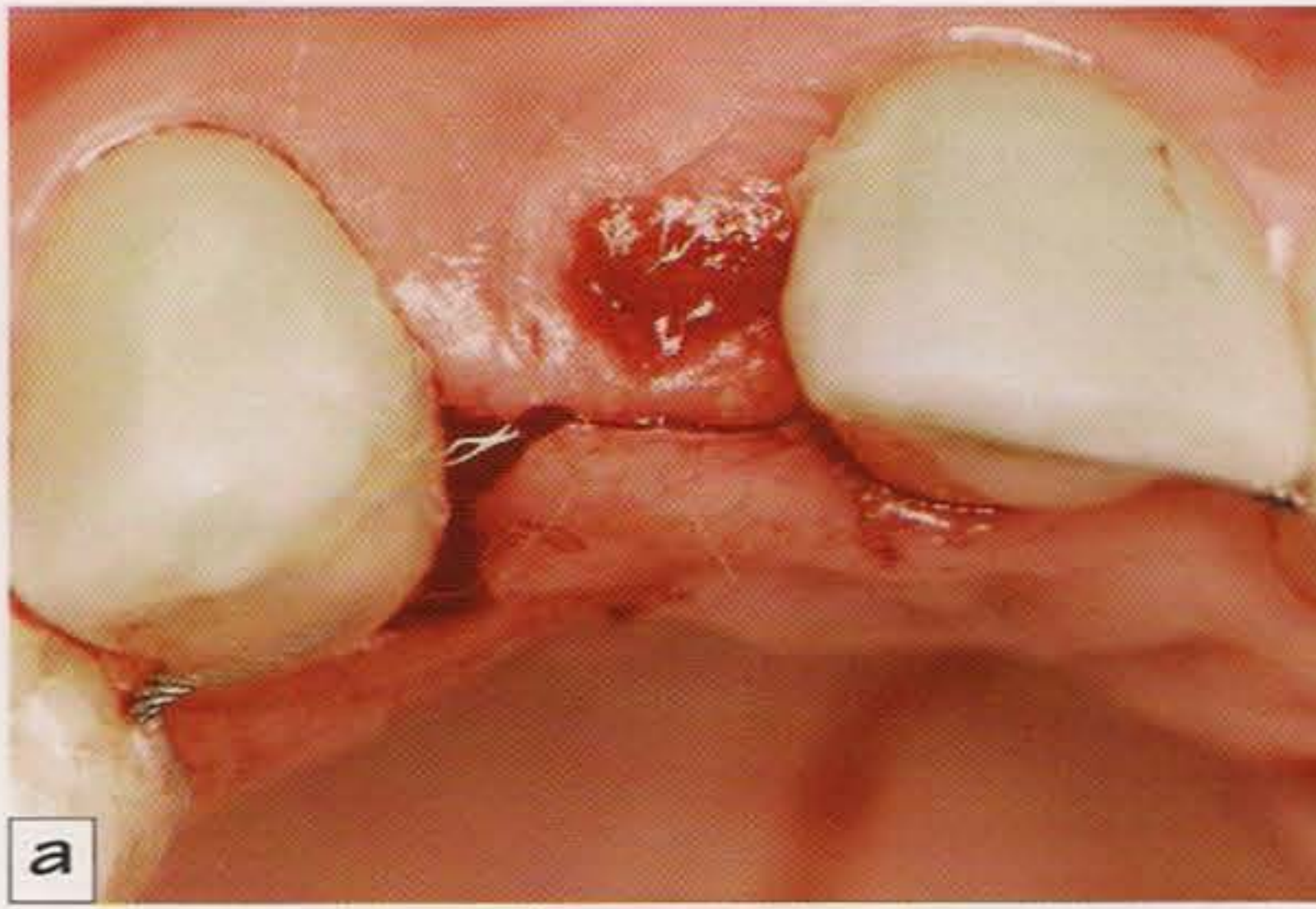
Transition from surgical treatment site to prosthetic treatment site. The transition from the surgical site to the prosthetic site should be planned in advance to avoid misunderstandings and to ensure that the patient experiences a seamless transition from one specialist to the other.

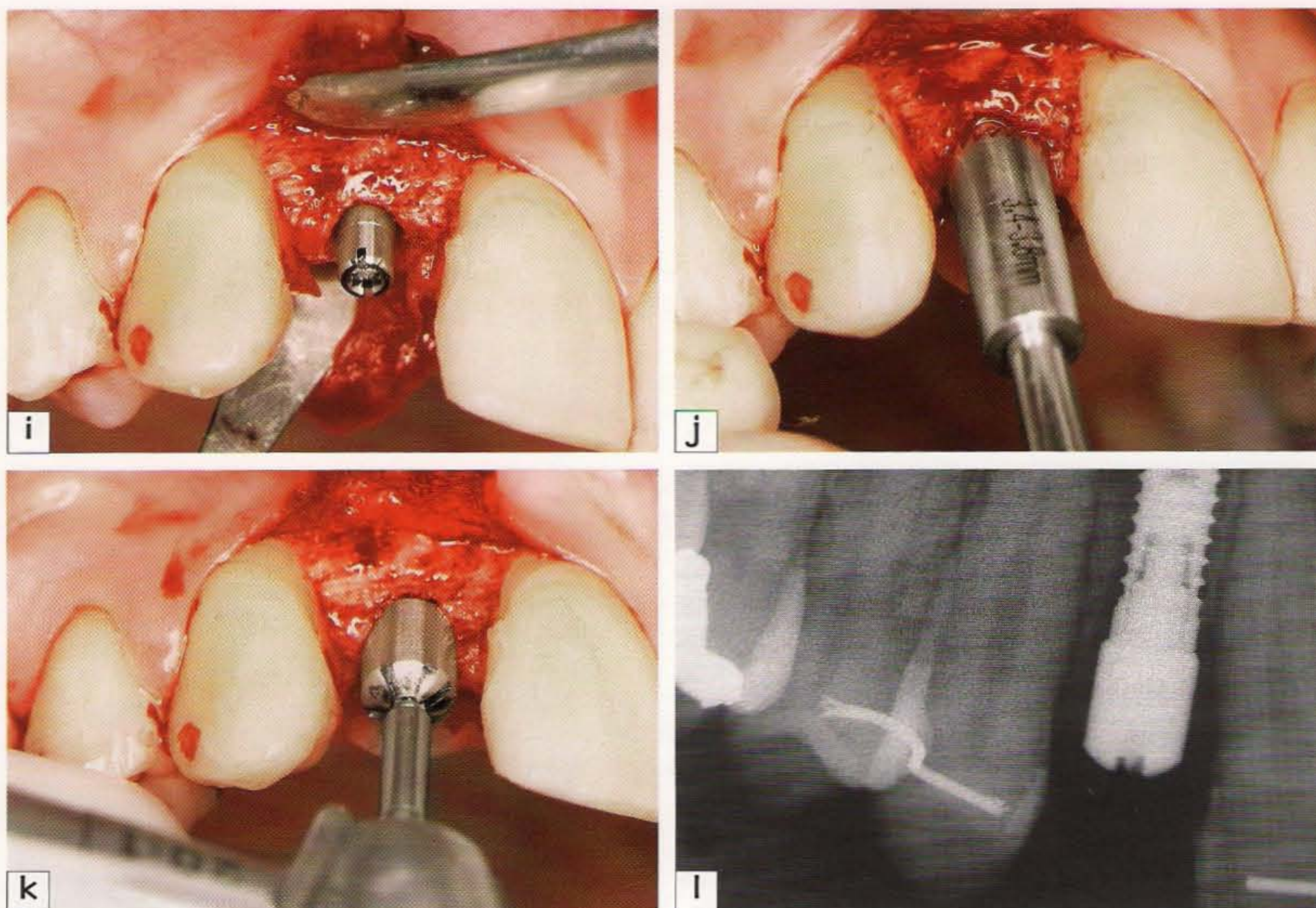
The prosthetic phase is discussed later in the chapter, after the surgical approaches to other types of maxillary anterior tooth loss are described.

Replacement of multiple maxillary anterior extraction sites

Five maxillary anterior teeth were to be extracted because of advanced periodontal disease (Fig 11-13). For reasons related to the performance of her professional duties, the patient wanted the implant-supported restoration to be placed as quickly as possible.







◀ ▲ **Fig 11-12** Drilling sequence and placement of an implant restoration for a maxillary right central incisor. (a) Creation of access to the bony site by raising a flap with a crestal incision. (b) Raised flap. Space is limited both mesiodistally and buccopalatally; the site can accept only a small-diameter implant. (c) Mesiodistal axis as directed by the restrictions of the surgical guide. (d) Buccolingual axis as directed by the restrictions of the surgical guide. It is inclined palatally and emerges on the lingual side of the proposed crown. (e) Insertion of the final drill in the implant site. (f) Coronoapical position of the implant. The implant neck lies above the line joining the cemento-enamel junctions of the adjacent teeth. A periodontal probe reveals that the gingival depth is 2.0 mm instead of the expected 3.0 mm. (g) New coronoapical position of the implant after the site has been prepared anew. The implant carrier indicates that the implant neck lies 1.5 mm below the crest. (h) Subcrestal position. The bone profiler must be used to seat the healing abutment. (i) Guide of the bone profiler in place. (j) Bone profiler in use. (k) The healing abutment is screwed in before the flap is sutured. (l) Control radiograph. Note the subcrestal level of the implant neck.

Presurgical preparation

Clinical and radiographic examinations

- Determination of the smile line (see Fig 11-13a)
- Assessment of the periodontal status of the teeth to be extracted (see Fig 11-13b) and the infected sites (Fig 11-13c)
- Diagnosis confirming the need to extract the affected maxillary anterior teeth

- Assessment of the status of the soft tissues, the relationship of the cervical margins of the teeth to be restored with the adjacent teeth, and the presence and quality of the papillae (see Fig 11-13b)
- Determination of the available bone height and width by means of a CT scan (see Figs 11-13d and 11-13e).

The CT scan is necessary because it:

- Permits assessment of the buccal plate to determine if it is wide enough to support an implant.
- Allows precise visualization of any concavities that would weaken the bone envelope necessary for implant support
- Helps to assess the severity of the periodontal disease.

Study casts: Preparation of a surgical guide

A nonrestrictive surgical guide was prepared that would provide the surgeon with the flexibility to adjust the approach if unexpected osseous obstacles were encountered because of the advanced periodontal disease (see Fig 11-13f).

Surgical phase

Extraction of teeth

Five maxillary anterior teeth were extracted because of severe periodontal disease (Fig 11-14a). Antibiotic therapy was started 3 days before surgery, and atraumatic extraction was performed with special care to preserve the buccal plate.

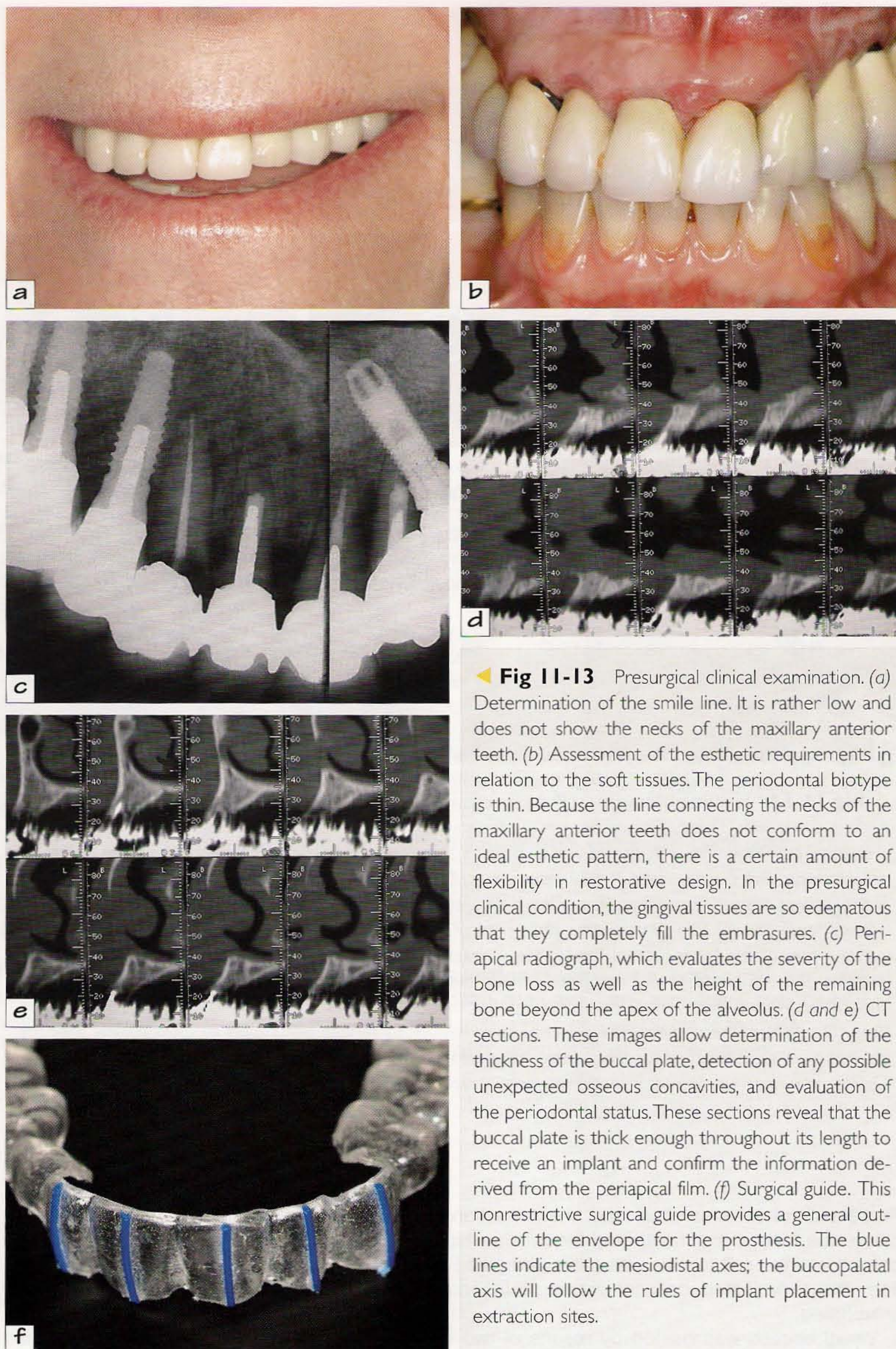
Placement of implants

Analysis of the osseous and gingival landmarks. The periodontal biotype was thin (see Fig 11-13b). The try-in of the surgical guide after tooth extractions revealed that the gingival tissue height was deficient (Fig 11-14b). The esthetic objective was to maintain the marginal gingiva and the papillae as close to their current level as possible. This goal was difficult to achieve because of the great amount of bone already lost, but fortunately the patient had a low smile line.

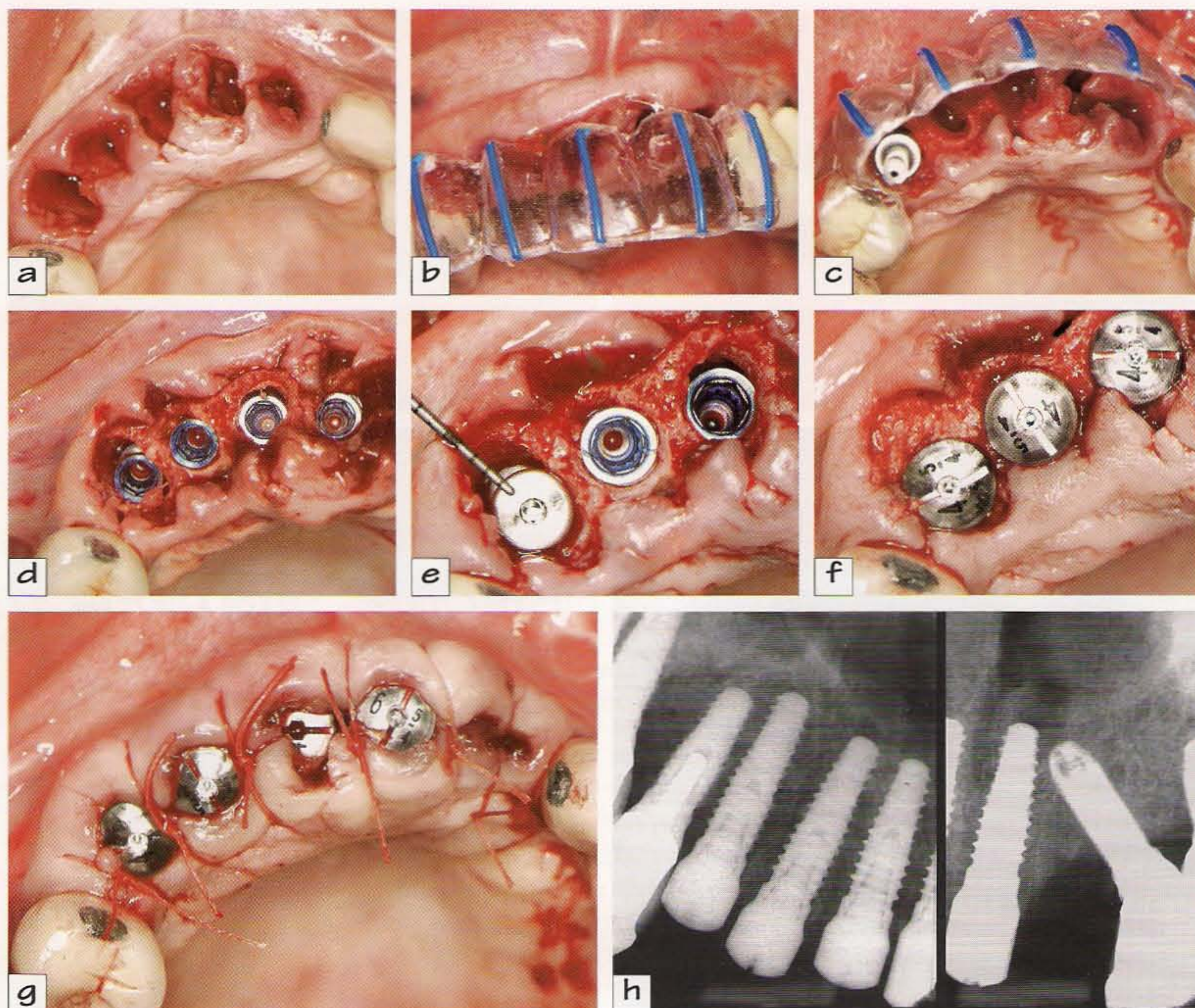
To provide the soft tissues with the maximum bone support, the 2-mm distance between the border of the buccal plate and the exterior edge of the implants was to be carefully respected.

Selection of implant number and design.

1. *Number of implants.* The treatment plan called for the fabrication of a five-unit restoration, but fewer than five implants were to be placed. Ideally, three would have been sufficient, and with this number there would have been no difficulty in maintaining the correct distance between implants. Because an immediate-loading protocol was planned, four implants were needed to provide the prosthesis with the best biomechanical support, even though optimal conditions for obtaining good esthetics were not fully present in this case. The site of the maxillary left lateral incisor had such a large osseous defect that it could not satisfactorily receive an implant. Had this site been available, it would have been easier to respect the correct minimum interimplant distance.
2. *Implant diameter and type.* To maintain at least at a minimally correct distance between implants, their diameter could be no larger than 4.0 mm. Narrow 3.3-mm-diameter implants would not have provided enough primary stability. These smaller implant diameters did not permit platform switching; therefore, four NT implants with roughened necks were selected. The roughened surface should encourage maintenance of the osseous crest at the best possible height.
3. *Implant length.* After the depths of the alveoli were measured and bone height was assessed on the radiographs, 13.0- and 15.0-mm-long implants were selected. To ensure primary stability of the implants, the alveoli were prepared 4.0 to 5.0 mm beyond their apices.



◀ **Fig 11-13** Presurgical clinical examination. (a) Determination of the smile line. It is rather low and does not show the necks of the maxillary anterior teeth. (b) Assessment of the esthetic requirements in relation to the soft tissues. The periodontal biotype is thin. Because the line connecting the necks of the maxillary anterior teeth does not conform to an ideal esthetic pattern, there is a certain amount of flexibility in restorative design. In the presurgical clinical condition, the gingival tissues are so edematous that they completely fill the embrasures. (c) Periapical radiograph, which evaluates the severity of the bone loss as well as the height of the remaining bone beyond the apex of the alveolus. (d and e) CT sections. These images allow determination of the thickness of the buccal plate, detection of any possible unexpected osseous concavities, and evaluation of the periodontal status. These sections reveal that the buccal plate is thick enough throughout its length to receive an implant and confirm the information derived from the periapical film. (f) Surgical guide. This nonrestrictive surgical guide provides a general outline of the envelope for the prosthesis. The blue lines indicate the mesiodistal axes; the buccopalatal axis will follow the rules of implant placement in extraction sites.



▲ Fig 11-14 Implant placement. (a) Postextraction view of the alveoli of five extracted teeth. (b) Surgical guide in the mouth. The guide indicates the mesiodistal orientation of the implant axes and the extent of the prosthetic envelope. The soft tissues are at a more apical level than the tooth necks; therefore, it will be difficult to prevent the expected gingival recession. (c) Determination of the axis of the first implant. The axis of the implant is more lingual than that of the natural tooth. The drill axis shows that the prosthetic envelope is being respected. (d) Clinical view after placement of the four implants. The site of the maxillary left lateral incisor is not suitable for an implant; this hinders maintenance of the recommended minimal distance between implants. Some implants do not completely fill the extraction alveoli. (e) Measurement of the gap between implants and the alveolar wall. At the maxillary right canine, the gap was greater than 1.5 mm, so it required filling. The gaps of the other alveoli were not large enough to require obturation. (f) Clinical view after the gap has been closed with autogenous bone harvested from the burs and placement of the healing caps. (g) Clinical view after suturing. (h) Postoperative radiographs with the implants in place.

Preparation of osseous sites. After the extractions were completed (see Fig 11-14a), the surgical guide was tried in the mouth and the relationship between the cervical margins of the proposed crowns and the soft tissues was examined (see Fig 11-14b). The soft tissues were some distance from those projected cervical zones of the crowns, indicating gingival recession should be anticipated.

Visual access was gained by means of two crestal incisions; this was essential in this case because of the severity of tissue damage from periodontal disease.

Drilling sequence. The typical drilling sequence was the classic technique followed without tapping. 3D positioning.

Reminder:

Implant positioning in a maxillary anterior extraction site was discussed in detail in chapter 5.

1. *Mesiodistal axis.* The mesiodistal axis of the implant is perpendicular to the axis of the crown it will support; the position is indicated by the surgical guide (Fig 11-14c).
2. *Buccopalatal axis.* This axis will differ from the axis of the extracted tooth by being inclined more palatally (see Fig 11-14c). This will allow a distance of at least 2 mm between the rim of the buccal plate and the external edge of the implant (Fig 11-14d).

A notch is prepared in the apical third of the alveolar wall with a round bur; the pilot drill is used to extend this notch beyond the apex.

3. *Coronoapical axis.* The implant should be placed 1 to 2 mm subcrestally, depending on the site. With NT implants, implant positioning is anticipated by the correct drilling depth.

Primary stability. Set at 40 Ncm, the drill stalls before the implant is completely seated in the alveolus. When the drill is reset to a torque of 50 Ncm, the implant reaches its final seating in the socket.

Filling of bone gaps and placement of healing caps. In this patient, the gaps between the implants and the buccal plate ranged from 0.5 mm to 2 mm. The gap at the site of the maxillary left canine had to be filled. The other gaps did not require obturation, but could be addressed if bone from filling of the canine gap was left over.

Before the gap was filled, a cover screw was placed to prevent the filling material from entering the implant aperture (Fig 11-14e). In the present case, a sufficient quantity of autogenous material was harvested from the NT burs, and this was used to eradicate the gap in its most coronal 2 mm. When this was accomplished, the cover screw was removed and replaced with a healing cap (Fig 11-14f).

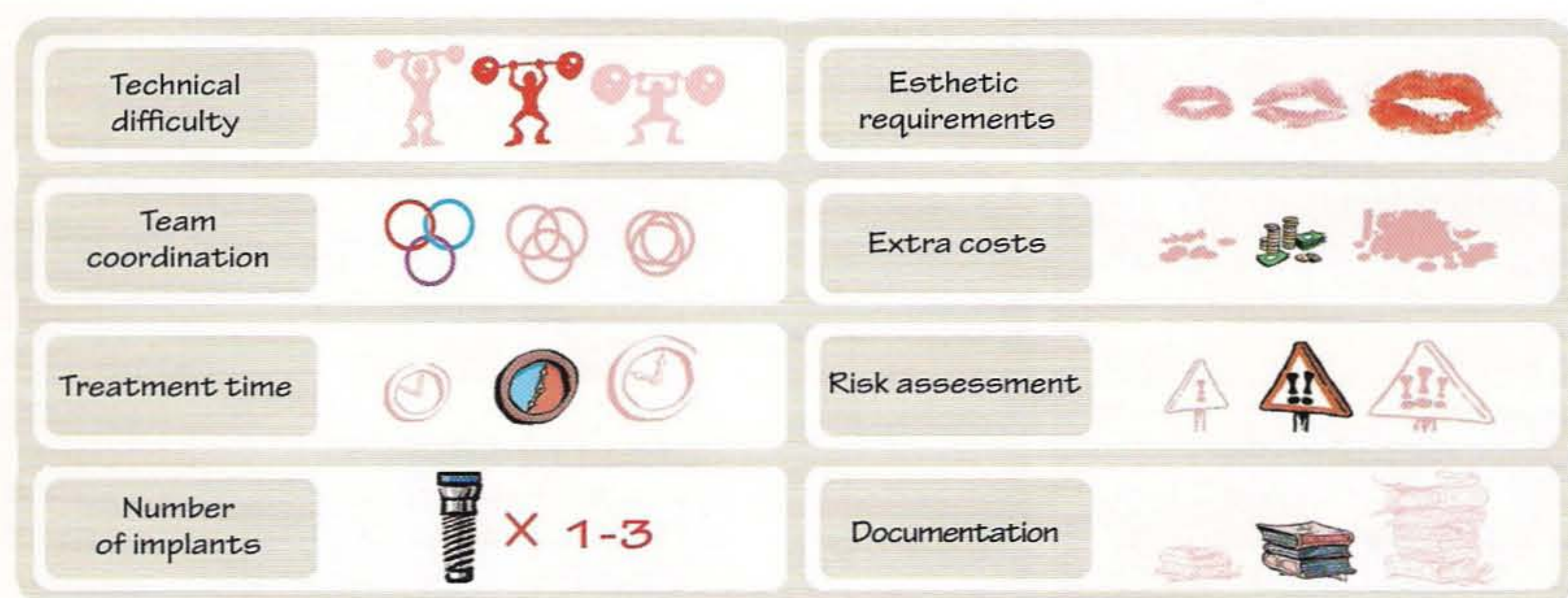
Even if the same practitioner is performing the surgical and prosthetic phases, the healing abutment is placed when the postoperative control radiograph is taken, to avoid soft tissue collapse.

Suturing. The gingiva is sutured closed around the abutments with single-point sutures (Fig 11-14g). This marks the end of the surgical phase.

Control radiograph. This radiograph will serve as a radiographic reference baseline to evaluate any future bone loss (Fig 11-14h).

Transition from surgical treatment site to prosthetic treatment site. The transition from the surgical site to the prosthetic site should be planned in advance, to avoid any misunderstandings and to ensure that the patient experiences a seamless transition from one specialist to the other.

After the surgical phase is completed, the prosthetic aspects must be considered.



▲ **Fig 11-15** Key information for treatment option 1.

Prosthetic phase: Treatment option 1

Screw-retained provisional prosthesis placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the abutments are prepared at chairside.

Reminder:

- This option is chosen when a screw-retained prosthesis is preferred and when the principal determinant of treatment is the psychologic comfort of the patient. The patient does not want to be deprived of a prosthesis, even briefly. The clinician delivers a prosthesis of one to three units, immediately after surgery.
- Larger prostheses are too complex to be fabricated satisfactorily at chairside.

Key information for treatment option 1

Figure 11-15 summarizes the key aspects of prosthetic treatment in accordance with treatment option 1.

Technical difficulty is average

The technical difficulty is average because the procedure is conducted by the clinician at chairside and it requires full attention to each detail.

Team coordination is limited

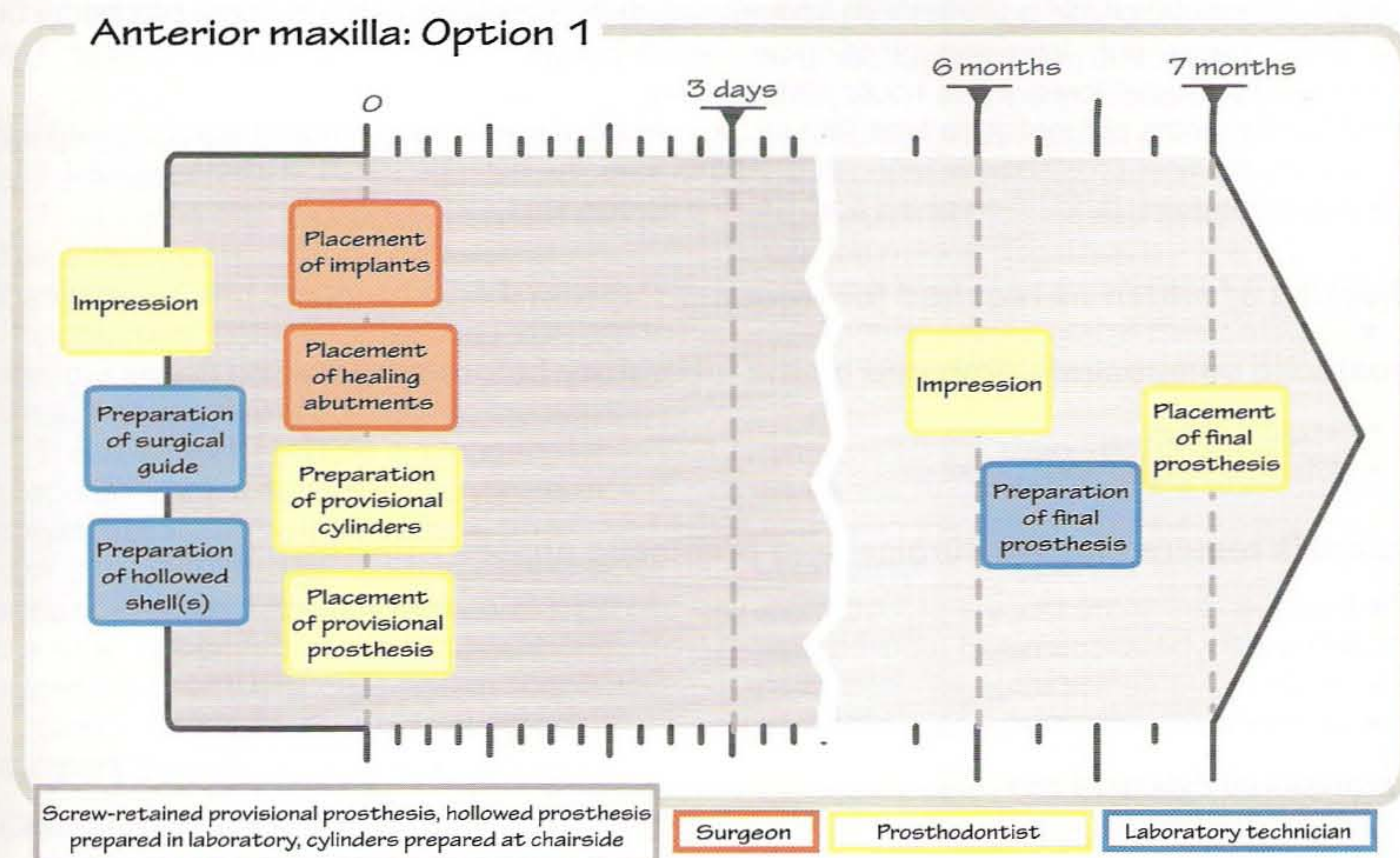
The prosthetic phase follows immediately after completion of surgery or is briefly delayed for a second session. The laboratory does not take part after the surgery.

Treatment time is average

The surgical and prosthetic appointments are combined and can last from 1 to 3 hours. They include 1 to 1.5 hours allotted to the surgical intervention and 1 to 2 hours for the prosthetic phase.

Number of implants: 1 to 3

The number of implants varies according to the indication, one for a single crown and more implants for a prosthesis. Larger prostheses should be prepared by the laboratory.



▲ **Fig 11-16** Sequence and timing of steps for treatment option 1. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Esthetic requirements are high

Esthetic considerations are important for this option, except for patients who have a low smile line. The criteria for implant placement are strict (see chapter 5).

Extra costs are moderate

Immediate loading is considered an alternative to provisional restoration with a resin-bonded tooth-supported prosthesis. Component and laboratory costs are similar, but the overall fee is higher because the prosthodontist spends time preparing the prosthesis instead of having it done by the laboratory.

Additional risk is moderate

Obtaining good primary stability is sometimes a problem, especially when implants are placed in extraction sites. When possible, it is preferable to splint the implants in a metal-reinforced prosthesis. The esthetic risk has not yet been fully evaluated.

Documentation in the literature is moderate

More and more studies are being published about this indication, which is the one that is best suited for immediate loading.

Sequence and timing of steps for treatment option 1

Figure 11-16 illustrates the treatment chronology for option 1:

- All the laboratory procedures are concluded before implant placement, including preparation of the surgical guide and the hollowed shell for the provisional prosthesis.
- Implants are placed in the usual way, according to the established rules for the procedure.

- The prosthetic phase is undertaken immediately after completion of the surgical procedure or with a pause only long enough to allow transition from one treatment site to another. The prosthesis is delivered within hours after surgery.
- After 6 months of function, a time that allows for soft tissue healing, implant stability is tested before the final prosthesis is fabricated. At this time, the esthetic status is also assessed.
- After that point, fabrication of the final prosthesis can start.

Checklist of materials required for treatment option 1

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Hollowed acrylic resin prosthetic shell

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)

If provisional cylinders are used

- Provisional cylinders (prosthodontist)
- Gold screws (prosthodontist)
- Try-in screws (prosthodontist)
- Disk for sectioning the cylinders (prosthodontist)
- Acrylic resin or resin composite for attachment of the hollowed shell to the cylinders and adjusting the margins of the denture (prosthodontist)

If provisional abutments are used

- Gingihue titanium abutments (Biomet 3i) (prosthodontist)
- Acrylic resin or resin composite (prosthodontist)
- Photopolymerizing lamp, if needed (prosthodontist)
- Burs (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

The presurgical and surgical procedures, discussed earlier in the chapter, are the same for all prosthetic options. When the surgical phase is concluded, the patient is provided with healing abutments and is ready for the prosthetic phase.

A case will be presented to illustrate the prosthetic phase according to option 1.

Case history

This case was used to illustrate the surgical phase of the restoration of a single maxillary anterior tooth in an extraction site (see Figs 11-3 to 11-12).

Provisional prosthetic phase

Generally, provisional cylinders are used to prepare a screw-retained prosthesis. This technique will be described later for treatment of the partially edentulous posterior region (see chapter 14, option 1).

In the present case, the screw-retained prosthesis was prepared with an original technique. With this procedure, esthetics can especially be well managed, as will be explained later.

Preparation of provisional abutment at chairside and placement of provisional prosthesis

The patient arrives at the prosthetic treatment site with a healing abutment attached to the implant (Fig 11-17a). The prosthodontist takes the hollowed shell, which has been prepared presurgically, and positions it precisely over the implant, with the aid of two wing tips that rest on the incisal edges of the adjacent teeth.

The healing cap is unscrewed and a Gingihue titanium abutment is selected to try in the mouth. The zones that have to be cut away are indicated with a felt marker (Fig 11-17b). The abutment is then trimmed and shortened slightly, less than it would be for a cemented restoration (Fig 11-17c). The abutment diameter is reduced from top to bottom, especially in the apical zone, which initially was the widest point. The reduction is intended to permit the soft tissues to occupy the greatest amount of space possible during the healing period.

The abutment aperture is plugged with cotton to prevent acrylic resin from penetrating it. The prepared shell is filled with acrylic resin and placed on the abutment, and the acrylic resin is polymerized. The wings that have been used to aid in seating the crown are then cut away with a disk (Fig 11-17d). The clinician uses a small round bur to make an opening through the lingual surface of the provisional crown to provide access for the gold fixation screw of the abutment, and the shell is bonded to the abutment (Figs 11-17e and 11-17f). Resin is added where needed, especially over the access hole to shape an adequate emergence surface.

Occlusion in extrusive and protrusive movements is checked, and the provisional crown is taken completely out of occlusion (Fig 11-17g).

Control radiograph

At the end of the prosthetic phase, a radiograph is taken to confirm correct seating of the restoration (Fig 11-17h). The image will also serve as a baseline to evaluate bone status over time.

Follow-up

The changes in the gingival margin should be evaluated over time. Figure 11-18a shows the soft tissues 3 months after placement of the provisional crown. Recession at the cervical margin was moderate and the papillae were stable over this period. Fig 11-18b, taken at 9 months, gives the impression that papillary recession was more severe, but this was due to the replacement of the original crown after it fractured in its fourth month of functioning. The new provisional crown was narrower apically than the one it replaced.

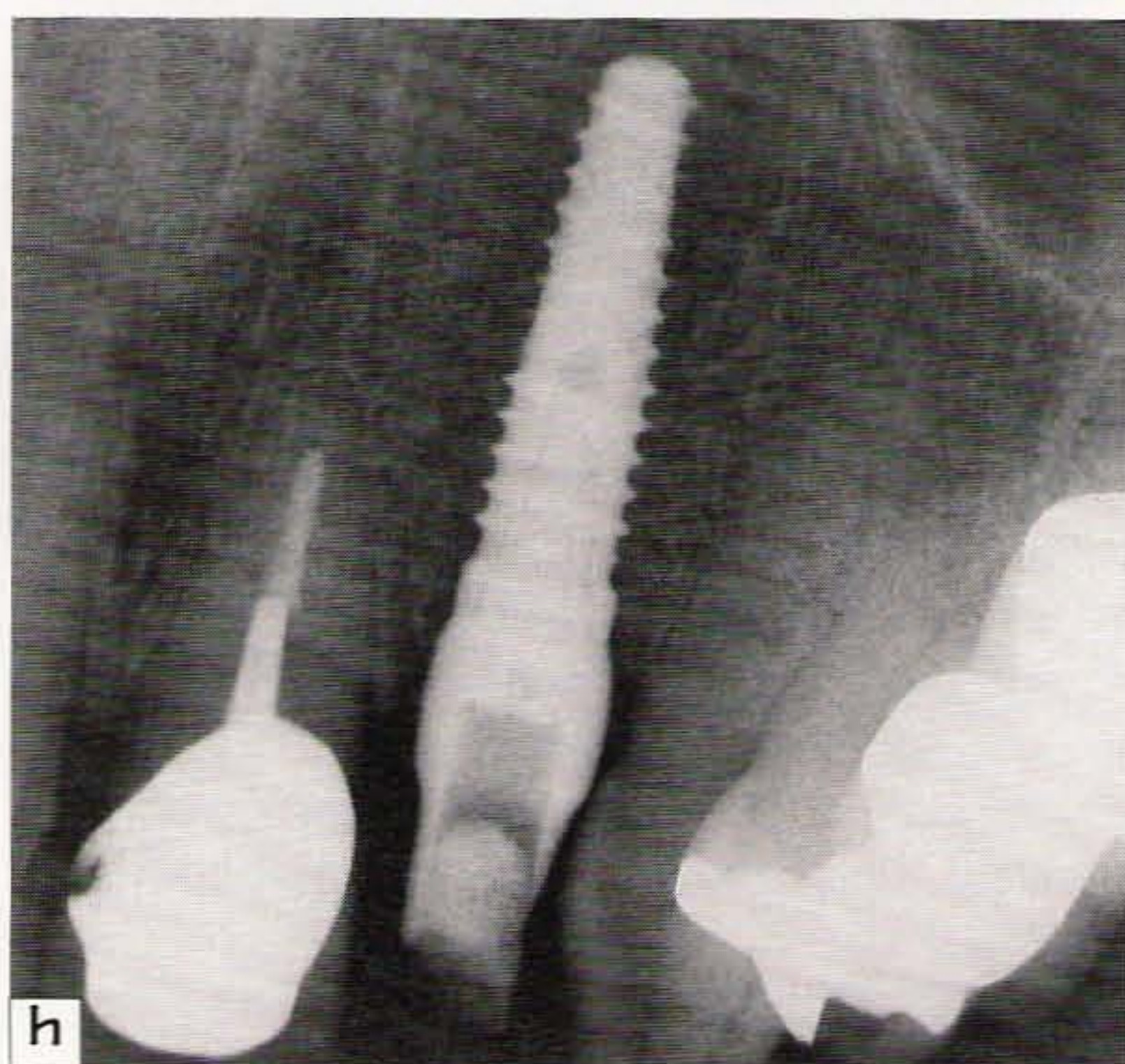
The 6-month follow-up radiograph of the provisional crown showed that the osseous landmarks remained stable and that there was no resorption reaching the level of the first implant thread (Fig 11-18c). The abutment, which was placed in contact with the soft tissues of the alveolus of the extracted tooth immediately after surgery, was never unscrewed since placement.

Prosthetic phase: Treatment option 2

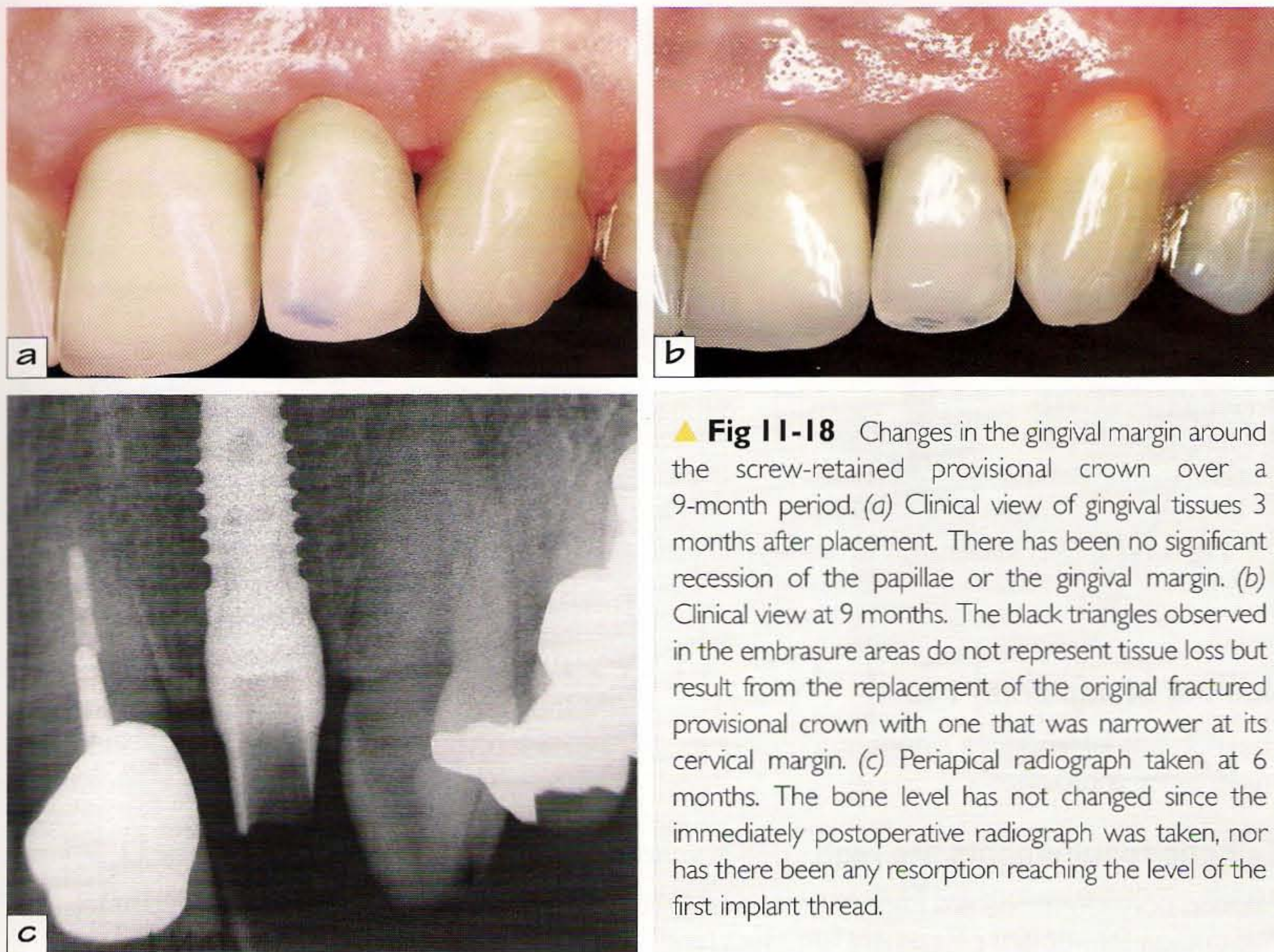
Screw-retained provisional prosthesis placed within 24 to 48 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

Reminder:

This option is selected when a screw-retained prosthesis is preferred and when the principal determinant of treatment is the physical comfort of the patient. The patient is not willing or able to endure a protracted combined surgical and prosthetic session that could demand up to 3 to 4 hours of uninterrupted time in the dental chair. The procedure is separated into two appointments of reasonable duration in 1 day or 2 consecutive days.



▲ **Fig 11-17** Preparation of the screw-retained provisional crown. (a) Clinical view at the start of the prosthetic phase. (b) Try-in and marking of the titanium abutment. (c) Reshaping of the abutment with a stone. Because the apical portion is particularly large, it will be reduced the most. (d) Adjustment of the crown on the abutment. The remnants of the positioning wing materials are still attached to the crown. (e) Crown bonded to the abutment. (f) Access path for the abutment screw (arrow). (g) Crown after it has been ground out of occlusion. Note the transparency of the mesial portion of the incisal edge, which has been especially reduced to ensure that it is out of occlusion. (h) Control radiograph. Note the titanium abutment, the gold screw, and the obturation material in the screw access path. (Prosthesis by Dr B. Jakubowicz-Kohen.)



▲ **Fig 11-18** Changes in the gingival margin around the screw-retained provisional crown over a 9-month period. (a) Clinical view of gingival tissues 3 months after placement. There has been no significant recession of the papillae or the gingival margin. (b) Clinical view at 9 months. The black triangles observed in the embrasure areas do not represent tissue loss but result from the replacement of the original fractured provisional crown with one that was narrower at its cervical margin. (c) Periapical radiograph taken at 6 months. The bone level has not changed since the immediately postoperative radiograph was taken, nor has there been any resorption reaching the level of the first implant thread.

Key information for treatment option 2

Figure 11-19 summarizes the key aspects of prosthetic treatment in accordance with treatment option 2.

Technical difficulty is low

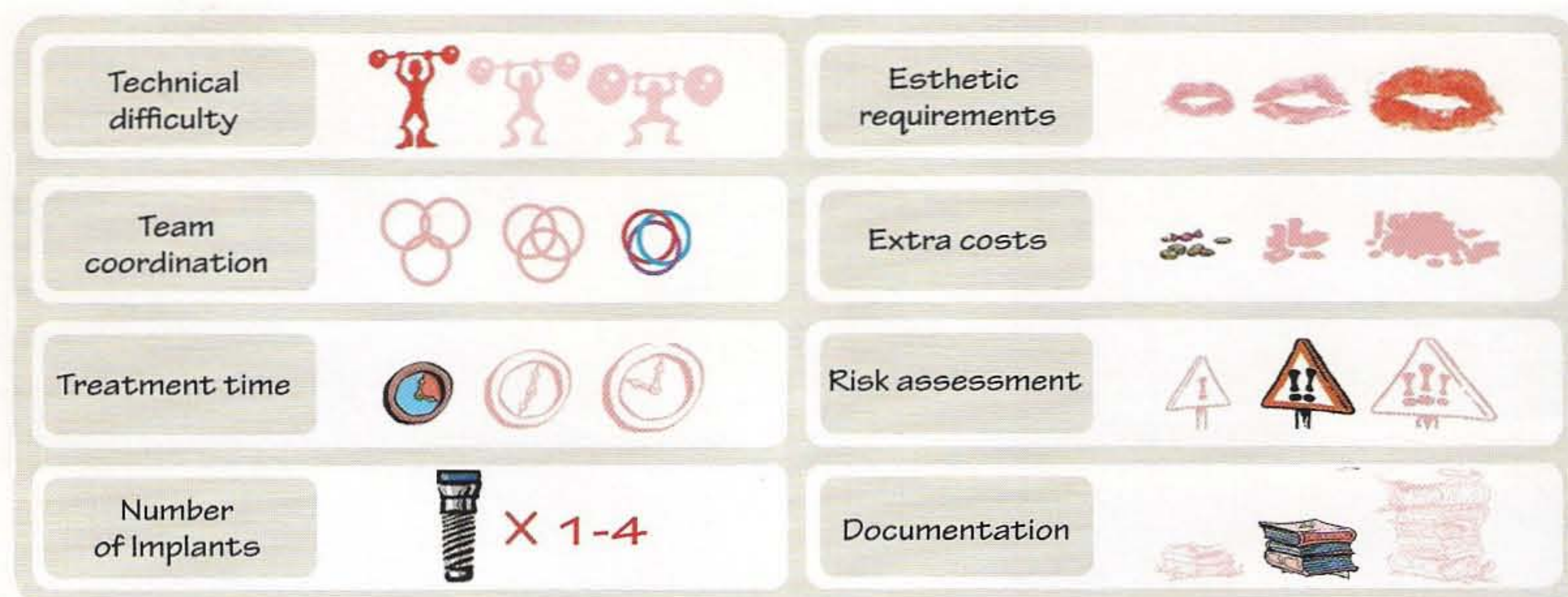
The screw access holes must emerge on the palatal surface of the prosthesis. The prosthetic phase is greatly simplified because the prosthesis is made in the laboratory.

Team coordination is tight

The surgical and prosthetic phases take place one after the other. An impression is taken immediately after implant placement and then delivered to the laboratory, which uses it to make the prosthesis. The laboratory starts working immediately after the surgery. The prosthesis is delivered as soon as possible, within 1 or 2 days. All the participants must weave their separate roles into a seamless and chronologically flawless joint enterprise.

Treatment time is limited

The surgical and the prosthetic phases are not immediately consecutive. They are carried out in stages of 1 to 2 hours for the surgical phase and 1 to 1.5 hours for the prosthetic phase. The prosthetic phase is divided into two sessions, one for taking the impression and one for delivering the prosthesis.



▲ **Fig 11-19** Key information for treatment option 2.

Number of implants: 1 to 4

The number of implants varies according to the indication, one for a single crown and more implants for a prosthesis.

Esthetic requirements are high

Esthetic considerations are important for this option, except for patients who have a low smile line. The criteria for implant placement are strict (see chapter 5).

Extra costs are low

Immediate loading is considered an alternative to provisional restoration with a resin-bonded tooth-supported prosthesis. Component and laboratory costs are similar, and the chair time is limited, so fees are lower for this option. For a multiunit prosthesis, component costs rise and the fee for immediate loading also rises, from low to average.

Additional risk is moderate

Obtaining good primary stability is sometimes a problem, especially when implants are placed in extraction sites. When possible, it is preferable to splint the implants in a metal-reinforced prosthesis. The esthetic risk has not yet been fully evaluated.

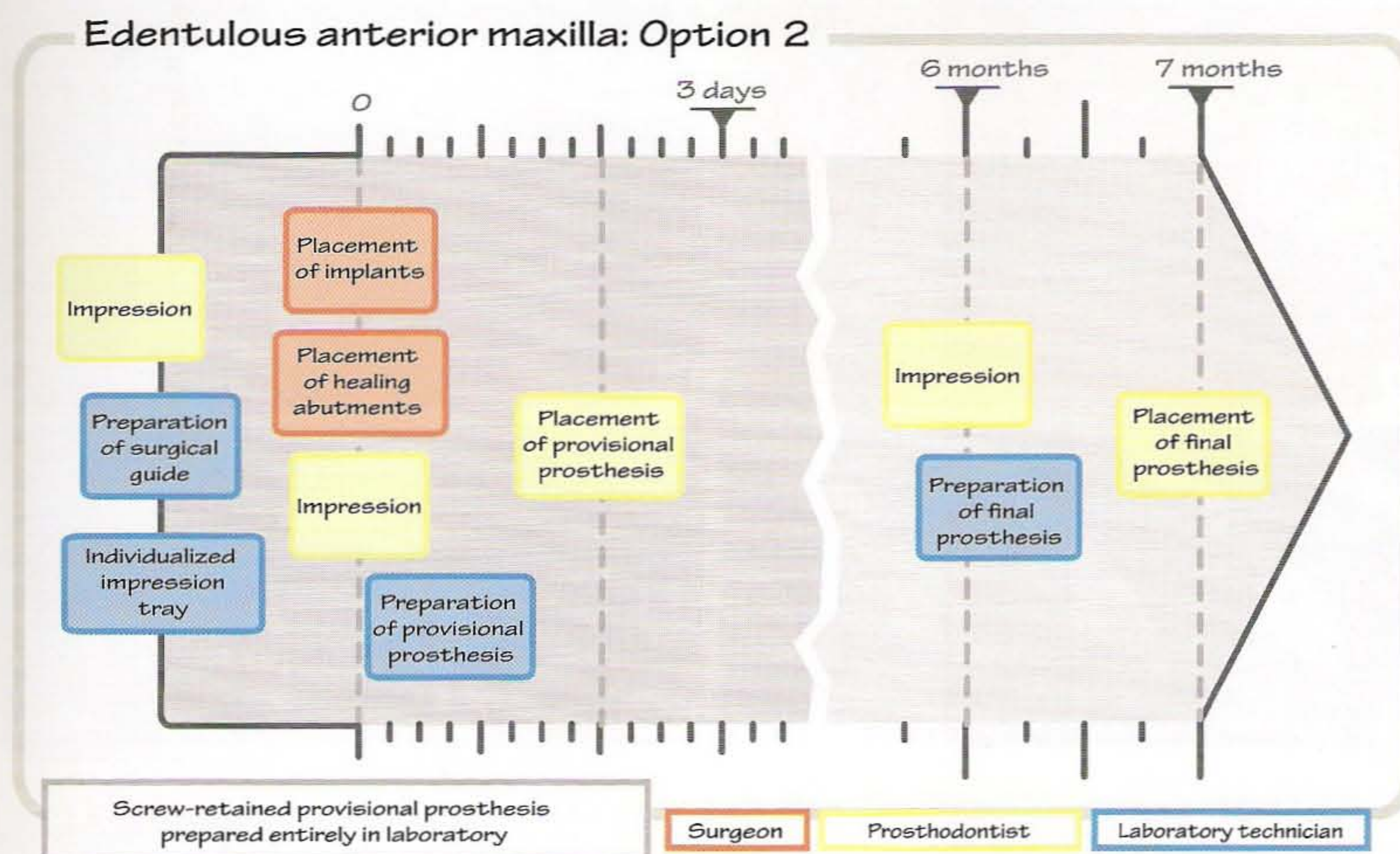
Documentation in the literature is moderate

More and more studies are being published about this indication, which is the one best suited for immediate loading.

Sequence and timing of steps for treatment option 2

Figure 11-20 illustrates the treatment chronology for option 2:

- The laboratory proceeds in two stages. Before implant placement, the laboratory makes the surgical guide and the individualized impression tray. Afterward, the laboratory constructs the prosthesis.
- Implants are placed in the usual way, according to the established rules for the procedure.
- The prosthodontist takes an impression immediately after completion of the surgical procedure.
- The prosthetic phase itself begins in the next distinct session, which takes place 2 to 48 hours later, depending on the location of the laboratory, its availability, and the number of units in the prosthesis.



▲ **Fig 11-20** Sequence and timing of steps for treatment option 2. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

- After 6 months of function, during which time the soft tissue matures, implant stability is tested, and the esthetic status of the provisional prosthesis is evaluated.
- Preparation of the final prosthesis then can begin in the usual manner.

Checklist of materials required for treatment option 2

Prosthetic components prepared by the laboratory before surgery

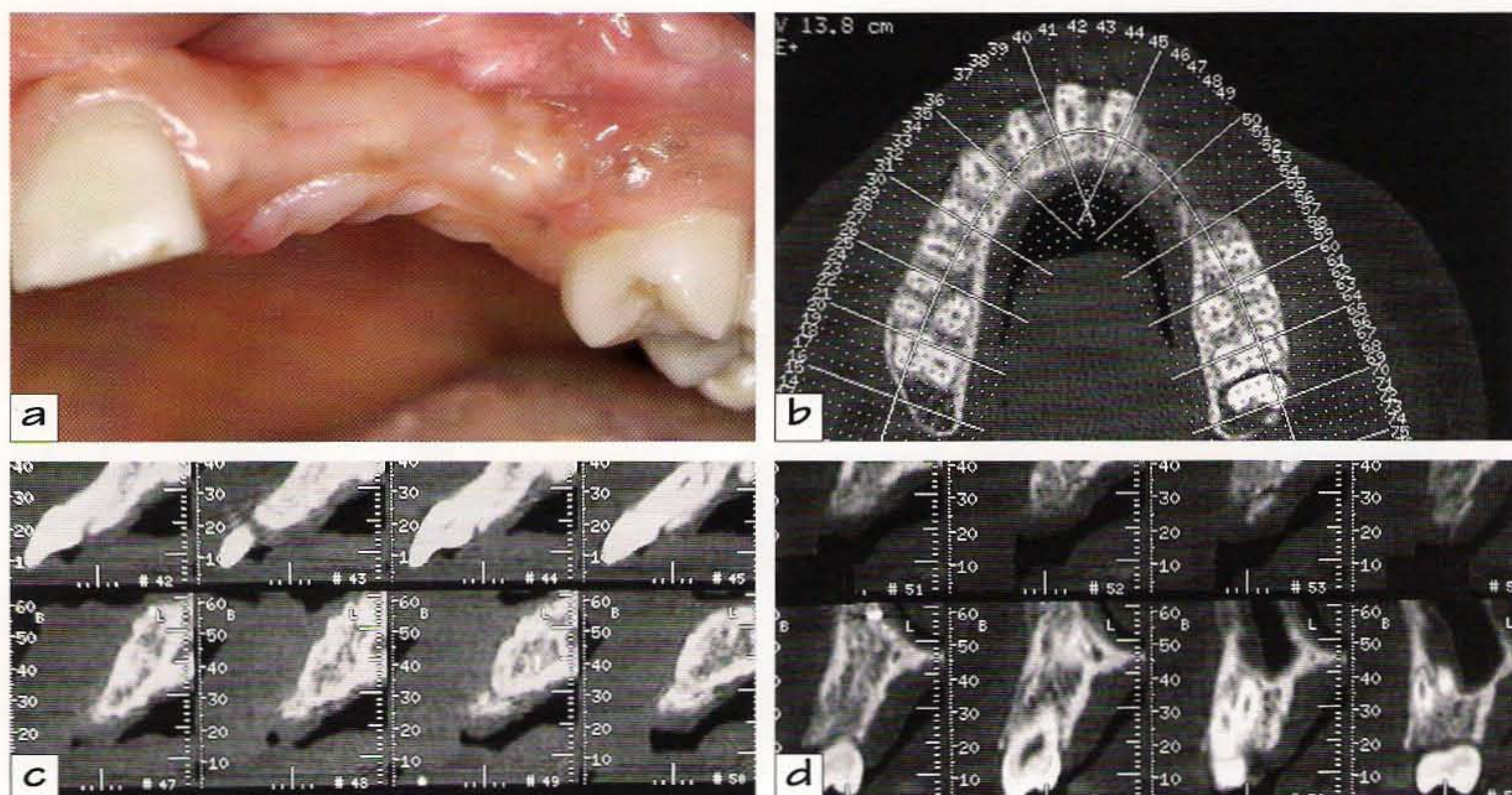
- Surgical guide
- Individualized impression tray, if needed

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Components needed for a pick-up impression with the appropriate number of impression copings (prosthodontist)

If provisional cylinders are used

- Laboratory analogs (laboratory)
- Provisional cylinders (laboratory)
- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)



▲ **Fig 11-21** Preoperative situation of a patient who had been in an automobile accident. (a) Clinical view revealing considerable bone loss. (b to d) CT scans showing the bone defect in the region that is to receive the implants.

If castable UCLA abutments are used

- Laboratory analogs (laboratory)
- UCLA abutments (laboratory)
- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

The presurgical and surgical procedures are the same for all prosthetic treatment options. When the surgical phase is concluded, the patient is provided with healing abutments and is ready for the prosthetic phase. The following case illustrates the prosthetic phase according to option 2.

Case history

A young woman who had been involved in an automobile accident a few months previously sought restoration of the maxillary left lateral incisor, the canine, and the first premolar teeth. She needed to be treated as quickly as possible because of an imminent trip abroad and wanted a lasting and secure provisional solution. The patient's smile line was low, her periodontal biotype was thick, and her teeth were short (Fig 11-21a). A radiographic examination revealed that the traumatic bone loss had been significant (Figs 11-21b to 11-21d).

Although the bone loss was relatively extensive, the remaining bone appeared to be adequate for the achievement of satisfactory primary stability with 13- to 15-mm-long implants. It was decided to place one implant for each missing tooth to satisfy the biomechanical requirements of immediate loading. Three 4-mm-diameter implants were positioned carefully to respect the correct distance between other implants and adjacent teeth. Two of the implants were Prevail implants, which sustained platform switching. The other was an NT implant, chosen to provide a harmonious emergence profile to the lateral incisor it supported, which was narrower than the other teeth.



▲ **Fig 11-22** Fabrication of an impression at chairside. (a) Clinical view of the healing abutments in place. (b) Placement of the impression copings. (c) Placement of impression tray on the implant necks.

Because of the shortness of the prosthetic crowns, a screw-retained prosthesis seemed appropriate. A provisional prosthesis with a metal framework was proposed because of the requirement for a lasting and secure provisional rehabilitation. The laboratory was to construct the prosthesis and deliver it 48 to 72 hours after the surgery.

Provisional prosthetic phase

Immediately after the surgery and placement of the healing caps, the patient was ready for the prosthetic phase (Fig 11-22a).

Impression

The prosthodontist removes the healing caps and screws the implant copings into the implant neck (Fig 11-22b). A control radiograph is not needed at this stage because implant connection is internal. The clinician takes an impression (Fig 11-22c) and a wax bite recording of the interocclusal relationship and sends them to the laboratory.

Laboratory procedures

The laboratory pours the impression with the implant analogs in position (Fig 11-23a). In this case, the metal framework was made on the UCLA abutments (Fig 11-23b), and three acrylic crowns were mounted on the framework (Fig 11-23c).

Delivery of prosthesis at chairside

After 48 hours, the prosthesis is placed directly on the necks of the implants. The prosthodontist verifies that the prosthesis is out of occlusion in centric relation as well as in all excursive movements, especially lateral excursions (Fig 11-23d). This is possible because of the absence of canine protection and presence of group function.

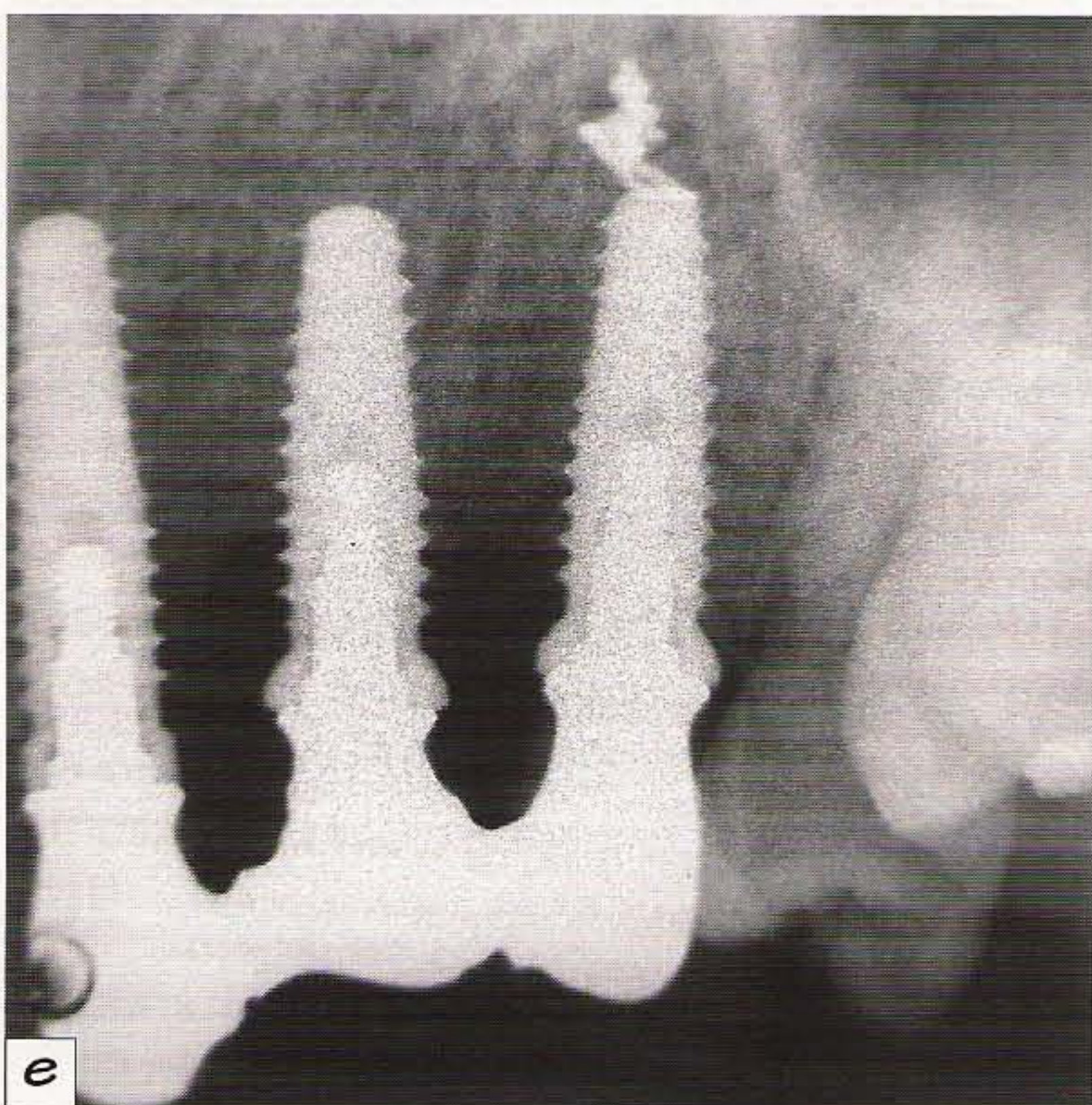
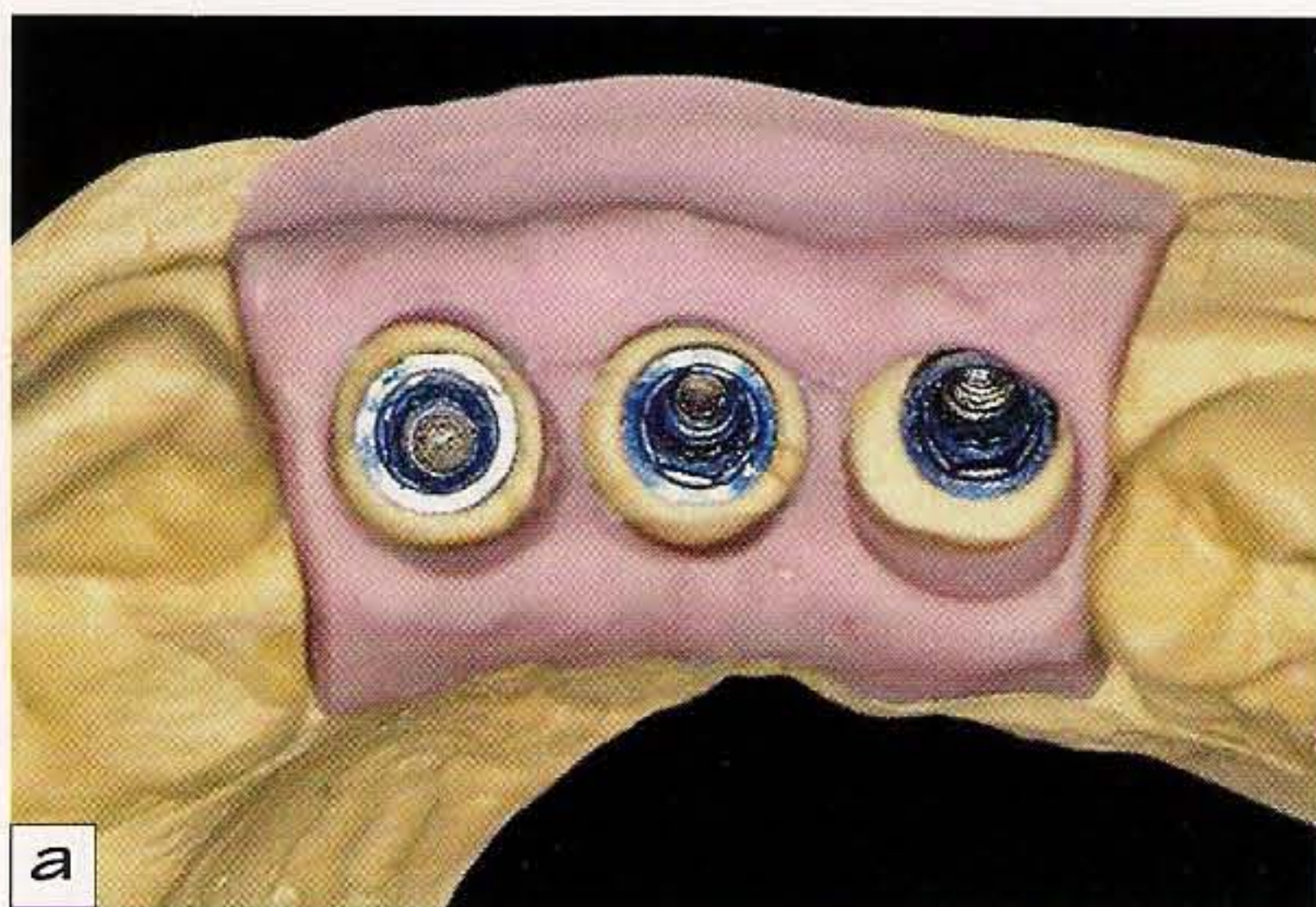
Control radiograph

After placement of the provisional prosthesis, a radiograph is taken (Fig 11-23e). This image will serve as a reference baseline to evaluate bone status over time. For this patient, the initial radiograph will allow assessment of any difference in bone response to the platform-switching Prevail implants and the NT implant.

Follow-up

When the patient was reevaluated after 6 months, the papillae between the teeth and the implants were present; however, the papillae between the implant-supported canine and the premolar were incomplete (Figs 11-24a and 11-24b). There was no recession at the cervical margins; therefore, esthetic management of the final prosthesis was easy and successful.

The follow-up radiograph taken 6 months after placement of implants revealed bone resorption up to the first thread around the NT implant but not around the Prevail implants (Fig 11-24c).



▲ **Fig 11-23** Fabrication of a prosthesis in the laboratory and placement of the prosthesis. (a) Cast poured in the laboratory with false gingiva. (b) Castable UCLA abutments to be used in fabrication of the metal framework of the prosthesis. (c) Screw-retained provisional prosthesis with a metal framework. (d) Prosthesis in place during occlusal adjustment. Note the carbon markings on some high spots. (e) Periapical radiograph taken after placement of the prosthesis. Platform switching has been employed on the two distal implants. The osseous gap has been filled with autogenous bone harvested during preparation of the implant sockets. (Prosthesis by Dr S. Molloy.)



▲ **Fig 11-24** Six-month follow-up. (a) Patient's smile. Because the smile line is low, the esthetic demands for this anterior prosthesis are only average. (b) Soft tissue condition. The gingival margins lie coronal to the prosthesis crowns, easing the achievement of good esthetic results. (c) Periapical radiograph taken at the 6-month recall. The bone level around the Prevail implants is unchanged from the immediately postoperative radiograph, but bone resorption has reached the first thread on the mesial aspect of the NT implant. (Prosthesis by Dr S. Molloy.)

Prosthetic phase: Treatment option 3

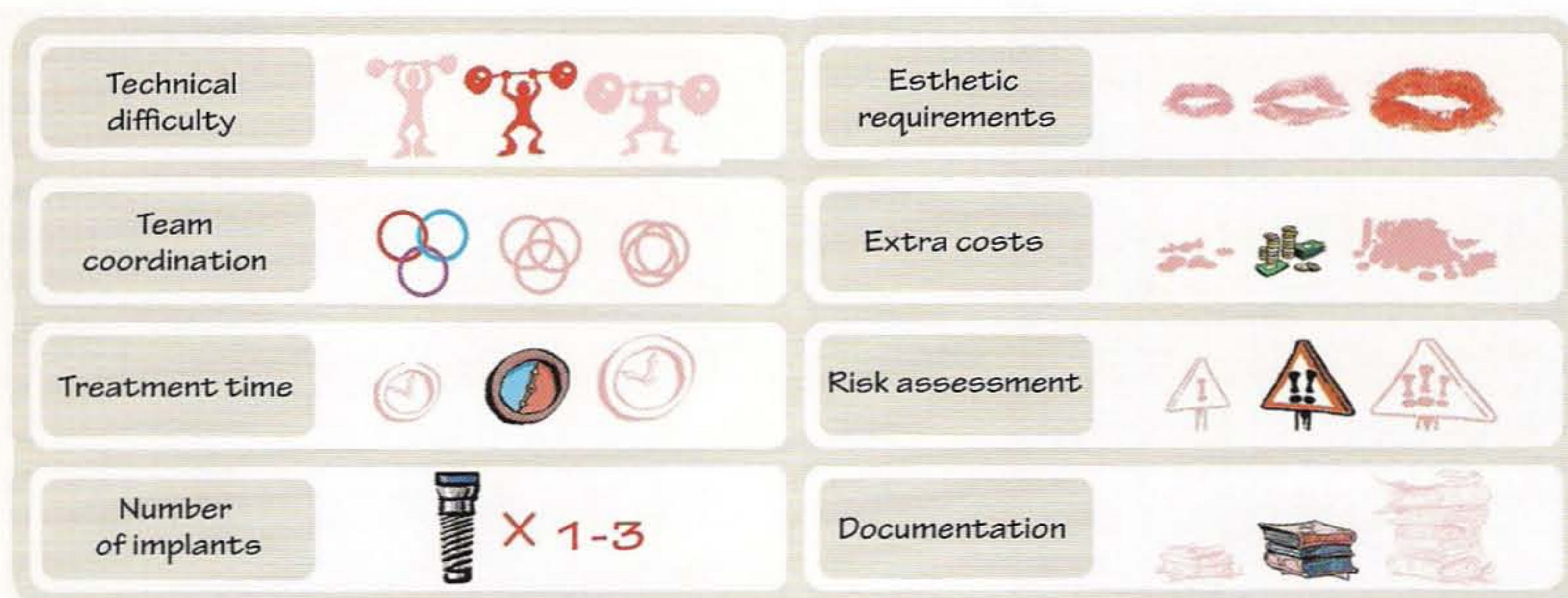
Cemented provisional prosthesis placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the abutments are prepared at chairside.

Reminder:

- This option is chosen when a cemented prosthesis is preferred and when the principal determinant of treatment is the psychologic comfort of the patient. The patient is requesting not to be deprived of a restoration, even briefly. The clinician can then deliver a prosthesis of one to three units immediately after surgery.
- The number of units varies from one to three. Larger prostheses are too complex to be satisfactorily made at chairside.

Key information for treatment option 3

Figure 11-25 summarizes the key aspects of prosthetic treatment in accordance with treatment option 3.



▲ **Fig 11-25** Key information for treatment option 3.

Technical difficulty is average

The technical difficulty is average because the procedure is conducted by the clinician at chairside and it requires full attention to each detail.

Team coordination is limited

The prosthetic phase follows immediately after completion of surgery or is briefly delayed for a second session. The laboratory does not participate in treatment after the surgery.

Treatment time is average

The surgical and prosthetic appointments are combined and can last from 1 to 3 hours. The total is distributed into 1 to 1.5 hours allotted to the surgical intervention and 1 to 2 hours for the prosthetic phase.

Number of implants: 1 to 3

The number of implants varies according to the indication, one for a single crown and more implants for a prosthesis. Larger prostheses should be prepared by the laboratory.

Esthetic requirements are high

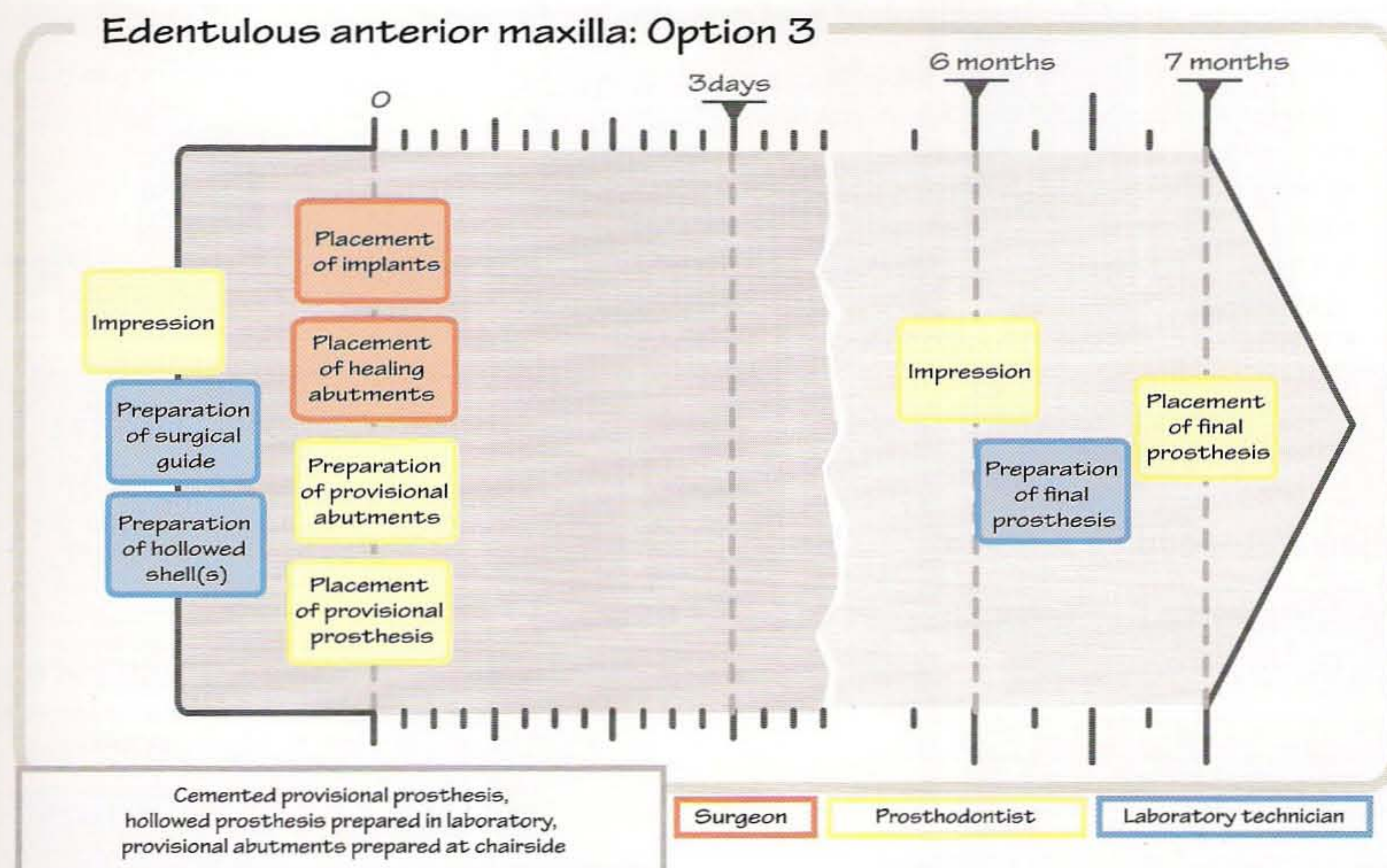
Esthetic considerations are important for this option, except for patients who have a low smile line. The criteria for implant placement are strict (see chapter 5).

Extra costs are moderate

Immediate loading is considered an alternative to provisional restoration with a resin-bonded tooth-supported prosthesis. Component and laboratory costs are similar, but the overall fee is higher because the prosthodontist spends time preparing the prosthesis chairside instead of having it fabricated by the laboratory.

Additional risk is moderate

Obtaining good primary stability is sometimes a problem, especially when implants are placed in extraction sites. When possible, it is preferable to splint implants in a metal-reinforced prosthesis. The esthetic risk has not yet been fully evaluated.



▲ **Fig 11-26** Sequence and timing of steps for treatment option 3. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Documentation in the literature is moderate

More and more studies are being published about this indication, which is the one best suited for immediate loading.

Sequence and timing of steps for treatment option 3

Figure 11-26 illustrates the treatment chronology for option 3:

- All the laboratory work is concluded before implant placement, including fabrication of the surgical guide and the hollowed shell for the provisional prosthesis.
- Implants are placed in the usual way, according to the established rules for the procedure.
- The prosthetic phase is undertaken immediately after completion of the surgical procedure or with a pause only long enough to allow for transition from one site to another. The prosthesis is delivered within hours after surgery.
- After 6 months of function, time that also allows for soft tissue healing, implant stability is tested before the final prosthesis is fabricated. At this time, the esthetic status is assessed.
- After this point, fabrication of the final prosthesis can start.

Checklist of materials required for treatment option 3

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Hollowed acrylic resin restoration

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Burs for trimming of the titanium abutments (prosthodontist)
- Acrylic resin or resin composite for attachment of the hollowed shell to the cylinders and adjustment of the margins of the denture (prosthodontist)
- Titanium abutments (prosthodontist)
- Try-in screws (prosthodontist)
- Gold screws (prosthodontist)
- Temporary cement (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

The presurgical and surgical procedures are the same for all prosthetic treatment options. When the surgical phase is concluded, the patient is provided with healing abutments and is ready for the prosthetic phase. A case will be presented to illustrate the prosthetic phase according to option 3.

Case history

This case has been presented to illustrate the surgical phase of the restoration of a single maxillary anterior tooth in an extraction site (see Fig 11-13). The patient's esthetic demands were high. The papillae and the gingival margin had to be preserved as much as possible. To fulfill this objective, a cemented restoration with a specific shaping of both the abutment and the crown was planned.

Provisional prosthetic phase

The patient arrives at the prosthetic site with a healing cap in place (Fig 11-27a).

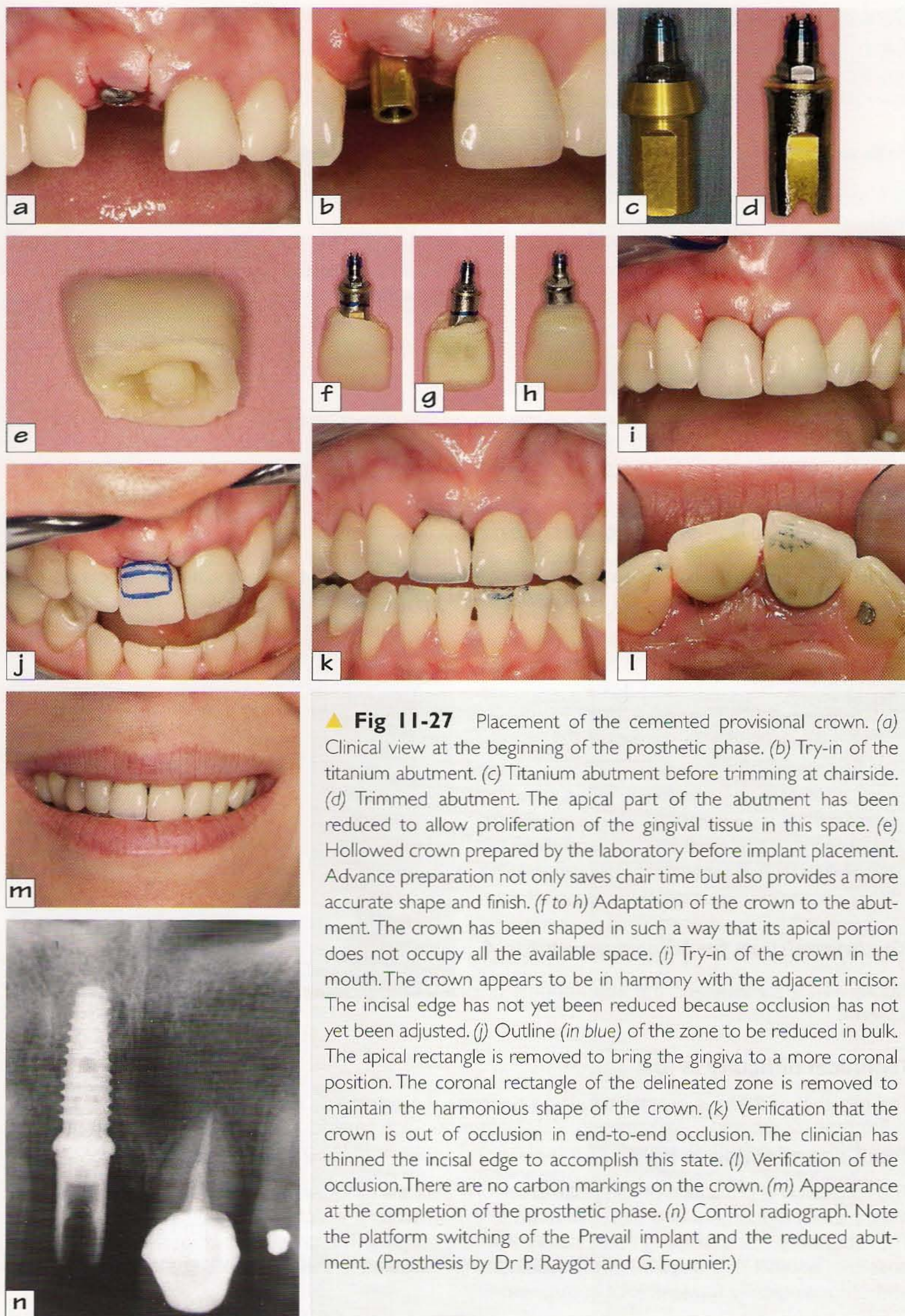
Preparation of provisional abutment at chairside and placement of provisional prosthesis

The clinician unscrews the healing cap. A Gingihue-type titanium abutment is selected and tried in to reveal the crown axis (Fig 11-27b).

The width of the abutment is trimmed throughout its entire length so that, when it is placed, the gingival tissue will be encouraged to proliferate in the created space during the healing period (Figs 11-27c and 11-27d). The clinician will later be able to use this gingival excess to improve esthetics when the final restoration is being prepared. The final crown, shaped in the usual way, will exert pressure on the papillae and push them in the coronal direction.

The prosthodontist has the hollowed crown that the laboratory has prepared in advance (11-27e). The apical border is not filled to the base of the abutment, in order to leave room for proliferation of the gingival tissue (Figs 11-27e to 11-27h). However, at the emergence level, the volume of the crown is designed to provide a full support to the gingival margin. At this stage, the clinician tries in the crown to verify its good adaptation to the soft tissue and its harmonious integration into the surrounding natural dentition (Fig 11-27i).

The clinician then begins to trim the gingival margin of the crown to relieve its bulk. The objective is to bring the gingiva in a more coronal position and to stabilize it there during the healing phase. This will allow the gingiva, during the final prosthetic phases, to move apically in a more natural position, in harmony with the supporting gingiva of the adjacent incisor. The zone to be adjusted is delineated with a marking pencil (Fig 11-27j), and the material is cut away. The crown is taken out of occlusion (Figs 11-27k and 11-27l). In this case, the incisal edge of the crown had to be considerably thinned to avoid contact with the opposing teeth during protrusive movements (Fig 11-27m). Figure 11-27m shows the patient's smile with the crown in place, at the completion of the prosthetic phase.



▲ **Fig 11-27** Placement of the cemented provisional crown. (a) Clinical view at the beginning of the prosthetic phase. (b) Try-in of the titanium abutment. (c) Titanium abutment before trimming at chairside. (d) Trimmed abutment. The apical part of the abutment has been reduced to allow proliferation of the gingival tissue in this space. (e) Hollowed crown prepared by the laboratory before implant placement. Advance preparation not only saves chair time but also provides a more accurate shape and finish. (f to h) Adaptation of the crown to the abutment. The crown has been shaped in such a way that its apical portion does not occupy all the available space. (i) Try-in of the crown in the mouth. The crown appears to be in harmony with the adjacent incisor. The incisal edge has not yet been reduced because occlusion has not yet been adjusted. (j) Outline (in blue) of the zone to be reduced in bulk. The apical rectangle is removed to bring the gingiva to a more coronal position. The coronal rectangle of the delineated zone is removed to maintain the harmonious shape of the crown. (k) Verification that the crown is out of occlusion in end-to-end occlusion. The clinician has thinned the incisal edge to accomplish this state. (l) Verification of the occlusion. There are no carbon markings on the crown. (m) Appearance at the completion of the prosthetic phase. (n) Control radiograph. Note the platform switching of the Prevail implant and the reduced abutment. (Prosthesis by Dr P. Raygot and G. Fournier.)

Control radiographs

Taken at the close of the prosthetic phase, the periapical radiograph showed the subcrestal position of the Prevail implant (Fig 11-27n). Future radiographs can be compared with the control to evaluate the bone response to the platform switching.

Follow-up

Two aspects of the follow-up of this case are particularly interesting. The first is to determine if the reduction in size of the abutment and the undercontouring of the crown had achieved their objectives. The second is to see if the Prevail implant was able to maintain the crestal level over time. Both choices were aimed at keeping the soft tissues closest to their original position.

The soft tissue response over time was assessed. After 1 week the gingival margin of the implant-supported crown was more coronal than that of the adjacent central incisor (Fig 11-28a), but the papillae had not maintained their original level. After 6 months, conditions had not changed, and the papillae as well as the gingival margin had stabilized (Fig 11-28b). Palatally, due to some gingival recession, the abutment was slightly exposed (Fig 11-28c).

The 6-month radiographic control of the provisional crown revealed that the crestal bone had remained at its original level (Fig 11-28d). The resorption that is normally observed up to the first thread had not taken place, because of the protective effect of platform switching.

Prosthetic phase: Treatment option 4

Cemented provisional prosthesis placed within 24 to 48 hours after surgery; the provisional abutments and the prosthesis are prepared in the laboratory.

Reminder:

- This option is chosen when a cemented prosthesis is preferred and when the principal determinant of treatment is the physical comfort of the patient. The patient is not willing or able to endure a protracted combined surgical and prosthetic session that could demand up to 3 to 4 hours of uninterrupted time in the dental chair. The procedure is separated into two appointments of reasonable duration.
- When the restoration involves a multiunit prosthesis, it should be reinforced with a cast metal bar.
- This option is also preferred when the prosthesis has more than three units or when the prosthodontist prefers to have the laboratory construct the prosthesis.

Key information for treatment option 4

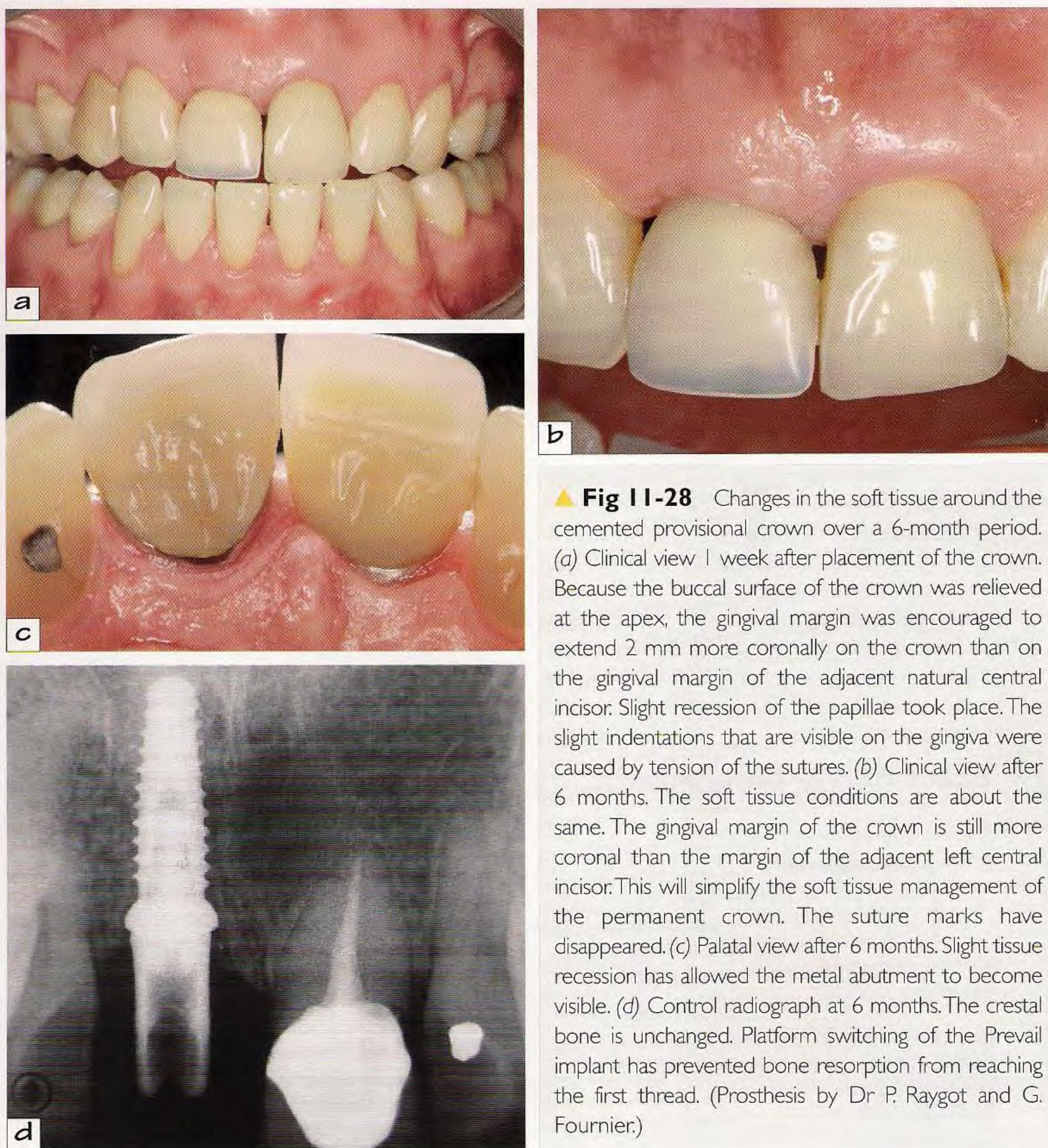
Figure 11-29 summarizes the key aspects of prosthetic treatment in accordance with treatment option 4.

Technical difficulty is low

The prosthetic phase is greatly simplified because the prosthesis is made in the laboratory.

Team coordination is tight

The surgical and prosthetic phases take place one after the other. An impression is taken immediately after implant placement and then delivered to the laboratory, which uses it to make the prosthesis. The laboratory starts working immediately after the surgery. The prosthesis is delivered as soon as possible, within 1 or 2 days. All these participants must weave their separate roles into a seamless and chronologically flawless joint enterprise.



▲ **Fig 11-28** Changes in the soft tissue around the cemented provisional crown over a 6-month period. (a) Clinical view 1 week after placement of the crown. Because the buccal surface of the crown was relieved at the apex, the gingival margin was encouraged to extend 2 mm more coronally on the crown than on the gingival margin of the adjacent natural central incisor. Slight recession of the papillae took place. The slight indentations that are visible on the gingiva were caused by tension of the sutures. (b) Clinical view after 6 months. The soft tissue conditions are about the same. The gingival margin of the crown is still more coronal than the margin of the adjacent left central incisor. This will simplify the soft tissue management of the permanent crown. The suture marks have disappeared. (c) Palatal view after 6 months. Slight tissue recession has allowed the metal abutment to become visible. (d) Control radiograph at 6 months. The crestal bone is unchanged. Platform switching of the Prevail implant has prevented bone resorption from reaching the first thread. (Prosthesis by Dr P. Raygot and G. Fournier.)

Treatment time is limited

The surgical and the prosthetic phases are not immediately consecutive. They are carried out in stages of 1 to 2 hours for the surgical phase and 1 to 1.5 hours for the prosthetic phase, which itself is divided into two sessions, one for taking the impression and one for delivering the prosthesis.

Number of implants: 1 to 4

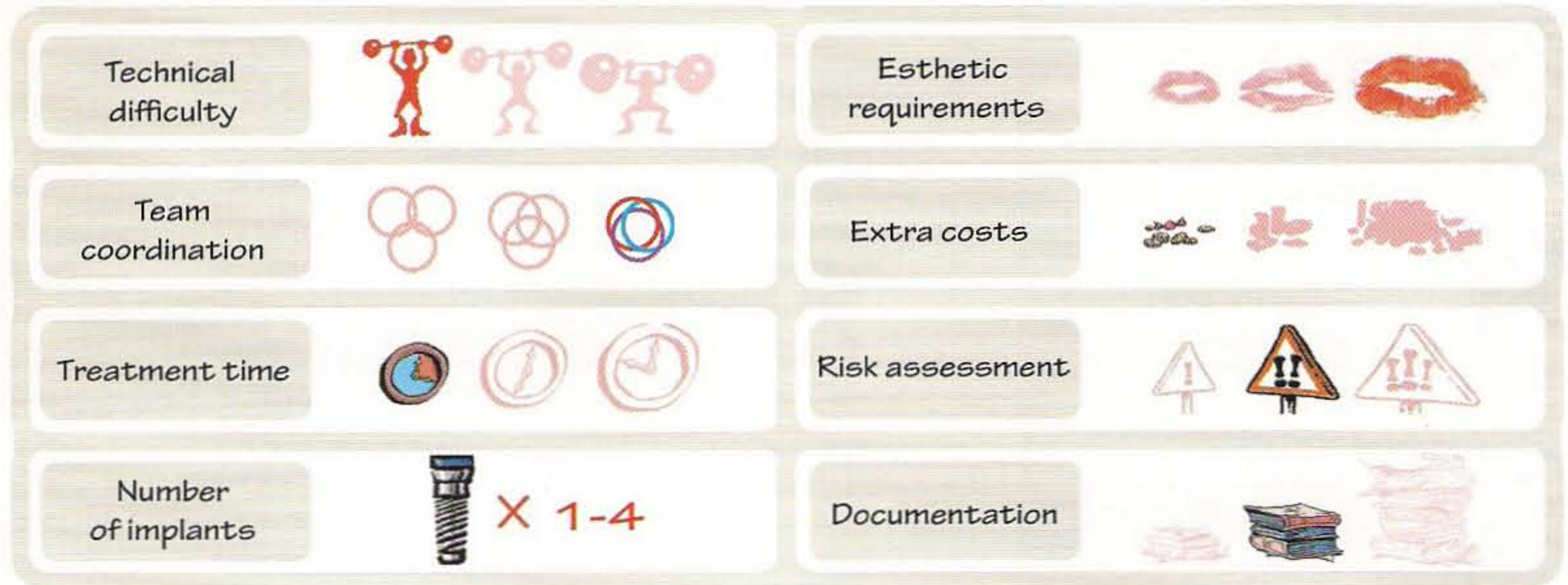
The number of implants varies from one for a single crown to three and more for a prosthesis.

Esthetic requirements are high

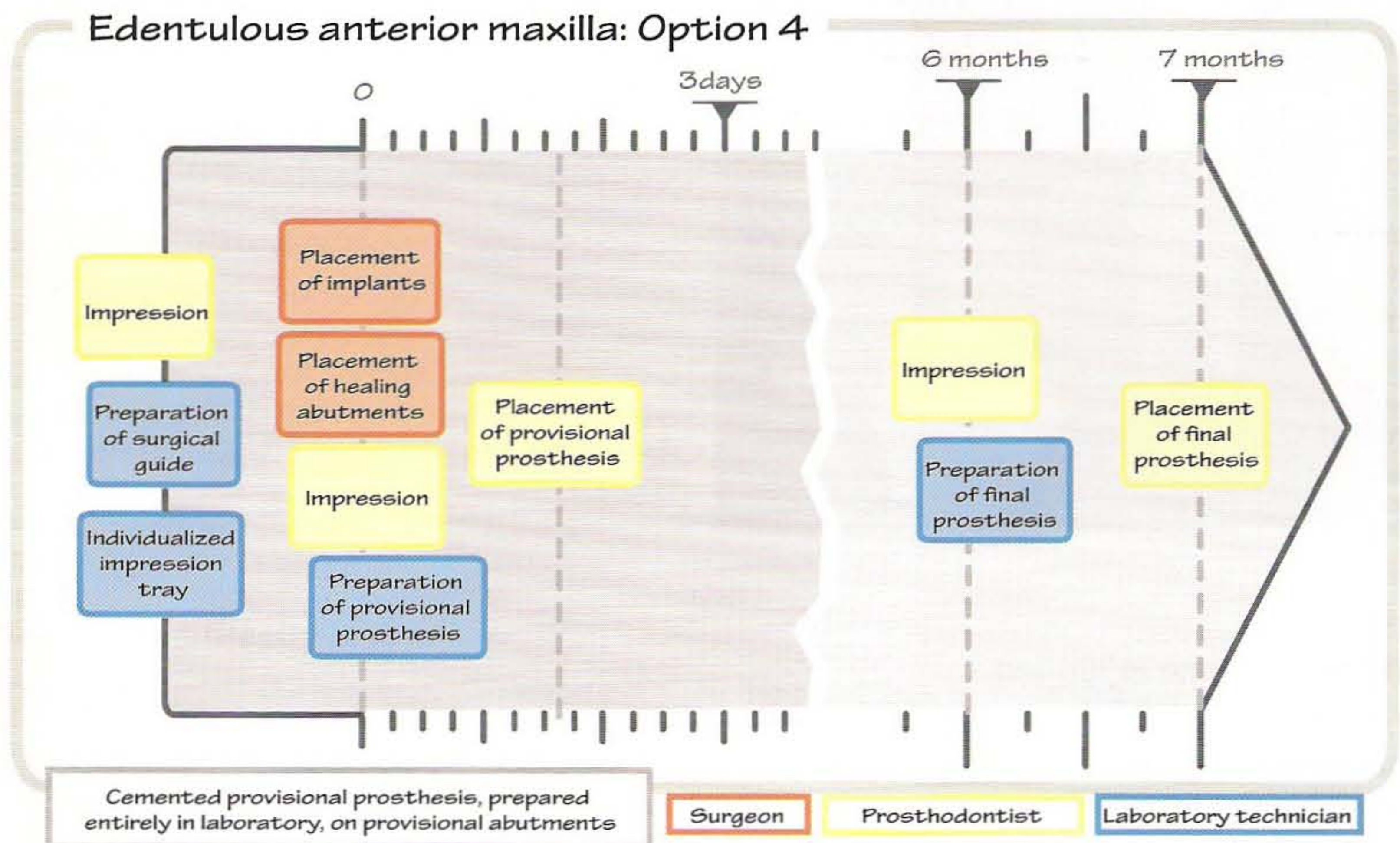
Esthetic considerations are important for this option, except for patients who have a low smile line. The criteria for implant placement are strict (see chapter 5).

Extra costs are low

Immediate loading is considered an alternative to provisional restoration with a resin-bonded tooth-supported prosthesis. Component and laboratory costs are similar, and the chair time is limited, so fees are lower for this option. For a multiunit prosthesis, however, component costs rise and consequently the fee for immediate loading rises also, from low to average.



▲ **Fig 11-29** Key information for treatment option 4.



▲ **Fig 11-30** Sequence and timing of steps for treatment option 4. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Additional risk is moderate

Obtaining good primary stability is sometimes a problem, especially when implants are placed in extraction sites. When possible, it is preferable to splint implants in a metal-reinforced prosthesis. The esthetic risk has not yet been fully evaluated.

Documentation in the literature is moderate

More and more studies are being published about this indication, which is the one best suited for immediate loading.

Sequence and timing of steps for treatment option 4

Figure 11-30 illustrates the treatment chronology for option 4:

- The laboratory proceeds in two stages. Before implant placement, the laboratory makes the surgical guide and the individualized impression tray. Afterward, the laboratory constructs the prosthesis.
- Implants are placed according to the established rules for the procedure.
- The prosthodontist takes an impression immediately after completion of the surgical procedure.
- The prosthetic phase itself begins in the next distinct session, which takes place 2 to 48 hours later, depending on the location of the laboratory, its availability, and the number of units in the prosthesis.
- After 6 months of function, which also represents the time it takes for the soft tissue to mature, implant stability is tested and the esthetic status of the provisional prosthesis is evaluated.
- Preparation of the final prosthesis can begin in the usual manner.

Checklist of materials required for treatment option 4

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Individualized impression tray

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Components needed for a pick-up impression with an appropriate number of impression copings (prosthodontist)
- Titanium abutments (laboratory)
- Laboratory analogs (laboratory)
- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)
- Temporary cement (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

The presurgical and surgical procedures are the same for all prosthetic treatment options. When the surgical phase is concluded, the patient is provided with healing abutments and is ready for the prosthetic stage. The following case will illustrate the prosthetic phase according to option 4.

Case history

This case was used to illustrate the surgical phase of the restoration of multiple maxillary anterior extraction sites (see Figs 11-13 and 11-14). The esthetic demands are not very high in this case because the patient's smile line is low. The patient was seeking functional restoration as soon as possible. Because of the combination of advanced periodontal disease and a thin periodontal biotype, an optimal result with respect to the soft tissues was not anticipated.

Provisional prosthetic phase

Immediately after surgery, the patient arrives at the prosthetic site with healing abutments in place (Fig 11-31a).

Impression

The prosthodontist removes the healing caps and screws the impression copings on the necks of the implants (Fig 11-31b). No radiographic control is needed because implant connection is internal. Tape is placed over the prepared impression tray to prevent diffusion of the impression material (Fig 11-31c). After the impression has been taken, the tape is removed and the heads of the copings are revealed (Fig 11-31d). The impression is sent to the laboratory for fabrication of a prosthesis with an extension and cast metal reinforcement.

The patient leaves the office wearing a rigid thermoformed bite tray in which the zone corresponding to the missing teeth is filled with acrylic resin (Fig 11-31e). This device serves as a rudimentary restoration that must be endured for 24 to 48 hours before the metal-reinforced provisional restoration is ready (Fig 11-31f).

Laboratory procedures

The laboratory pours the impression carrying the laboratory analogs (Fig 11-32a) and adjusts the abutments to the proper shape (Fig 11-32b). The acrylic resin prosthesis is mounted on the abutments (Fig 11-32c). The prosthesis, which has an extension, is reinforced with a cast metal bar (Figs 11-32d and 11-32e) and sent to the prosthodontist together with the abutments and a positioning key (Fig 11-32f).

Delivery of prosthesis

Within 48 hours, the prosthodontist removes the healing abutments one by one, replacing each with its prosthetic abutment (Fig 11-33a). All abutments are attached with a 20-Ncm torque. The prosthodontist places the prosthesis on the abutments and checks the dynamic occlusion. Contacts in protrusive movements are relieved to bring the prosthesis out of occlusion (Figs 11-33b and 11-33c).

In this case, after delivery of the prosthesis, the gingiva was still severely edematous. The gingival margins were well adapted, but the spaces that should have been filled by the papillae were empty (Figs 11-33d and 11-33e). The conditions made soft tissue management difficult, but the low smile line of the patient helped to mask the problem (Fig 11-33f).

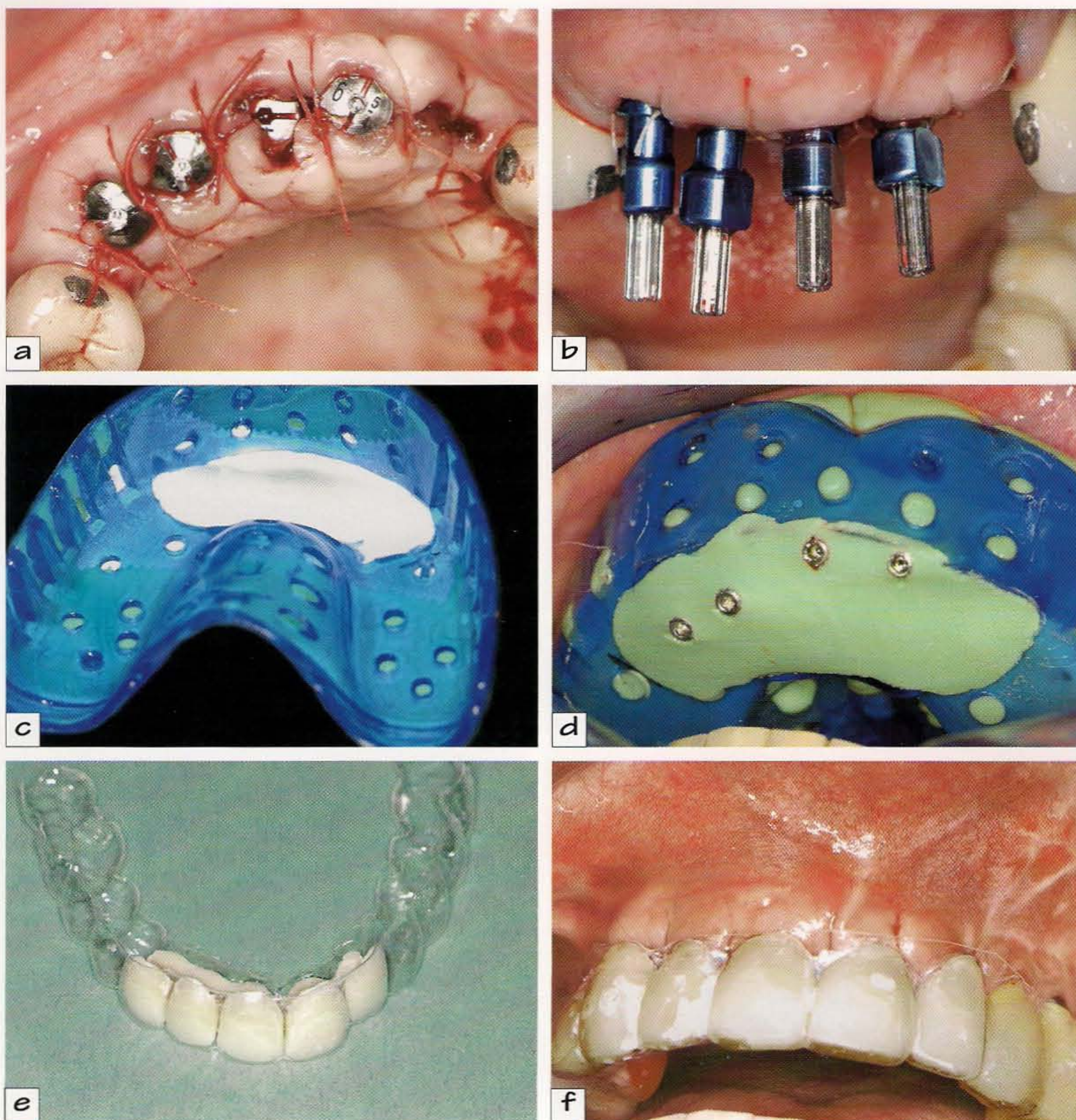
Control radiographs

After placement of the provisional prosthesis, a radiograph is taken (Fig 11-33g) to serve as a baseline reference to allow evaluation of the bone status over time.

Follow-up

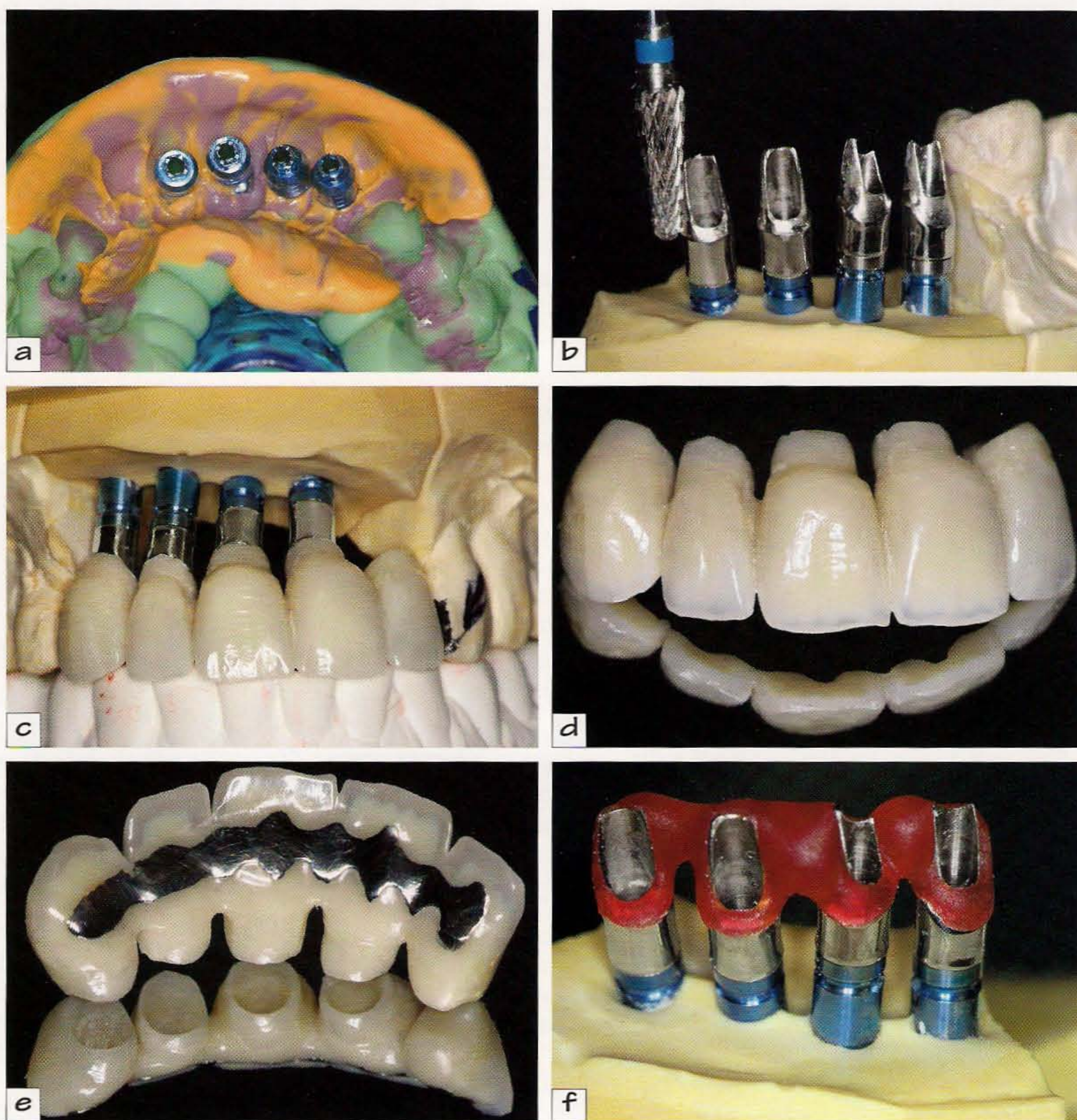
The changes that occurred to the gingival landmarks over 6 months are depicted in Fig 11-34a. The gingiva had receded significantly from the central incisors but quickly stabilized. The situation was similar to the 1-week postoperative control.

The interimplant crests had all been resorbed and were incapable of properly supporting the papillae (Fig 11-34b). Gingival grafts may be placed at some future time to manage the problem.



▲ **Fig 11-31** Fabrication of an impression. (a) Clinical view at the beginning of the prosthetic phase. (b) Placement of the implant copings. (c) Placement of tape over the impression tray. The tape covers the impression tray to prevent extrusion of the impression material. (d) Placement of the impression tray. During the setting of the impression material, while the tape is still in place, the screws of the impression copings are located with finger pressure. After the impression has set, the tape is removed, revealing the screws of the impression copings. (e) Bite tray prepared in the laboratory before teeth extraction. The spaces corresponding to the teeth that are to be extracted are filled with acrylic resin; the tray can be worn as a rudimentary denture until the provisional prosthesis is ready. (f) Bite tray in the mouth. This is a reasonably acceptable esthetic solution for the next 24 hours. The bright spots are light reflected on the resin of the tray. (Prosthesis by Dr P. Raygot and G. Fournier.)



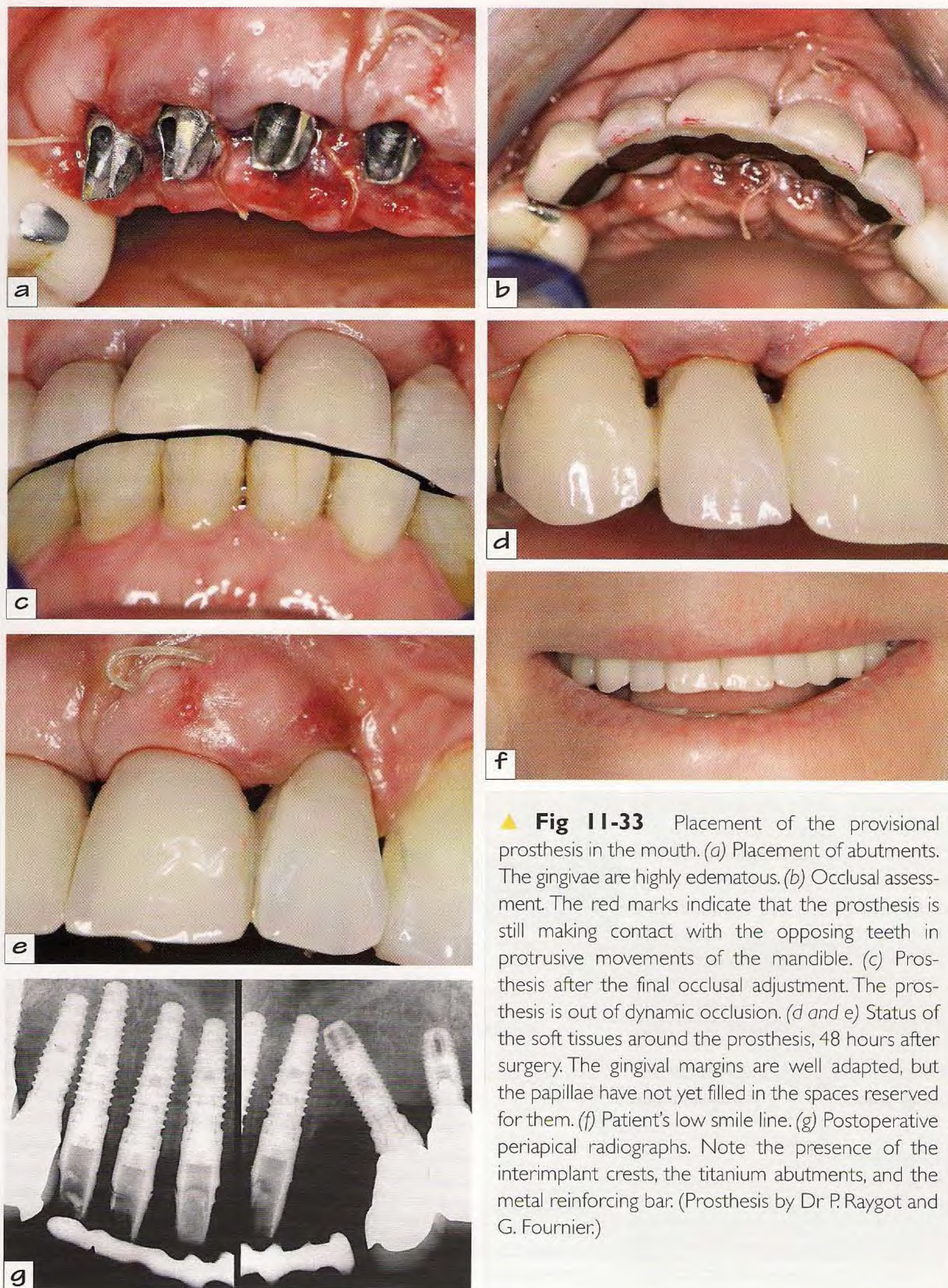


▲ **Fig 11-32** Fabrication of the provisional prosthesis. (a) Impression with implant analogs in place. (b) Trimming of the abutments with a laboratory bur. (c) Prosthesis on the articulator. Note the distal extension. (d) Buccal view of the prosthesis and its extension. (e) Prosthesis with the cast metal bar. (f) Abutments in their positioning key. (Prosthesis by Dr P. Raygot and G. Fournier.)

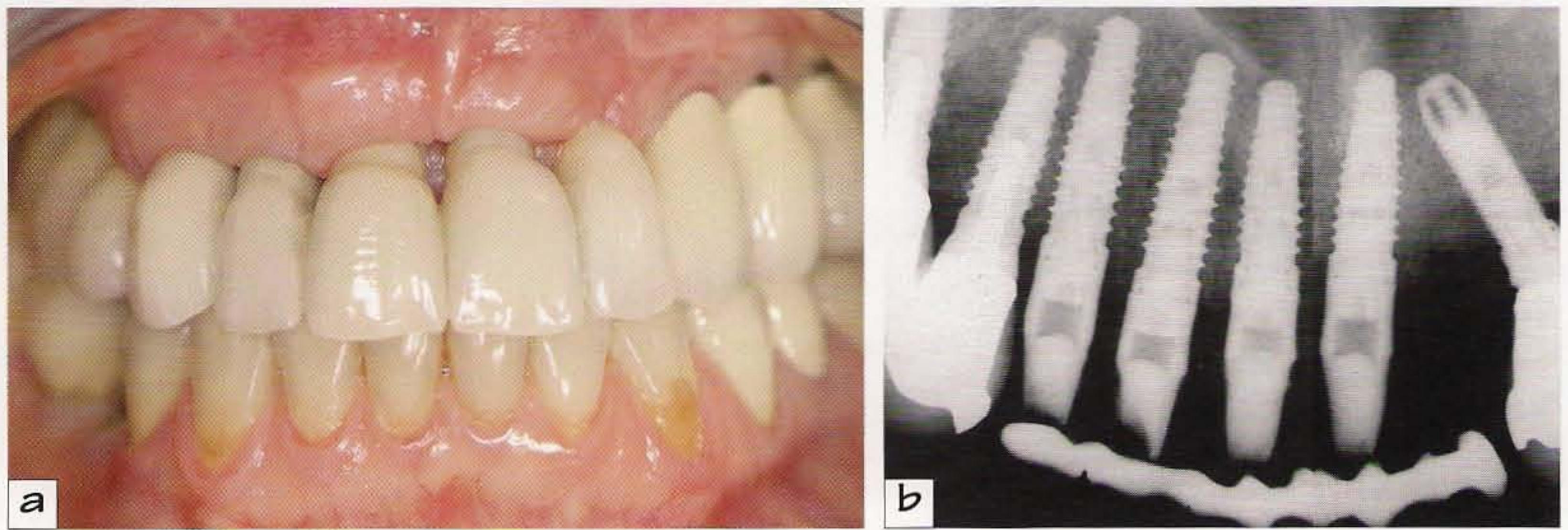
Treatment variant: Patient with a thick periodontal biotype

The patient's periodontal biotype is important to the approach to and outcome of treatment. While the biotype of the patient described in the previous case was thin, the biotype of the patient described in the following section was thick (Fig 11-35a).

This patient presented for restoration of a segment of the anterior maxilla. The radiographic examination revealed advanced periodontal disease requiring tooth extractions (Fig 11-35b).



▲ **Fig 11-33** Placement of the provisional prosthesis in the mouth. (a) Placement of abutments. The gingivae are highly edematous. (b) Occlusal assessment. The red marks indicate that the prosthesis is still making contact with the opposing teeth in protrusive movements of the mandible. (c) Prosthesis after the final occlusal adjustment. The prosthesis is out of dynamic occlusion. (d and e) Status of the soft tissues around the prosthesis, 48 hours after surgery. The gingival margins are well adapted, but the papillae have not yet filled in the spaces reserved for them. (f) Patient's low smile line. (g) Postoperative periapical radiographs. Note the presence of the interimplant crests, the titanium abutments, and the metal reinforcing bar. (Prosthesis by Dr P. Raygot and G. Fournier.)



▲ **Fig 11-34** Follow-up of the peri-implant tissues over time. (a) Clinical situation 6 months after placement of the prosthesis. There has been a notable recession of the gingival margins and the papillae, especially between the central incisors (compare with Fig 11-33d). The gingival recession around the pontic and the adjacent crowns is not as evident. The gingiva now appears to be much healthier than it was preoperatively and has been stabilized since the first week postoperatively. (b) Periapical radiograph taken at 6 months. There has been some overall bone loss, and some interimplant crests have resorbed from the level of the abutment to the level of the first threads. (Prosthesis by Dr P. Raygot and G. Fournier.)

The treatment plan included immediate loading of a provisional prosthesis and reduction of the marked anterior overbite. Three 4-mm-diameter, 13-mm-long conical NT implants were placed to restore the entire anterior segment (Figs 11-35c and 11-35d). A cemented prosthesis, reinforced with an integrated metal bar, was constructed in the laboratory (Figs 11-35e and 11-35f). The embrasures were not pronounced but they were filled with gingiva when the prosthesis was placed (see Fig 11-35e).

One week after delivery of the prosthesis, considerable recession of the papillae between the incisors was noted (Fig 11-35g). However, at the 3-month recall examination, the gingiva had stabilized at a more coronal position (Fig 11-35h). The positive gingival response was in marked contrast to that of the previously described patient (see Fig 11-34a); the difference can probably be attributed to the difference in their periodontal biotypes.

Prosthetic phase: Treatment option 5

Cemented provisional prosthesis placed within 24 to 48 hours after surgery; the final abutments and the prosthesis are prepared in the laboratory.

Reminder:

- This option is chosen when a cemented prosthesis is preferred and when the principal determinant of treatments are esthetics and the physical comfort of the patient.
- For this option, final titanium or zirconia abutments are trimmed and placed. They are not unscrewed at any time during the prosthetic phase. This prevents disruption of the high level of formed epithelial attachment.
- This option is selected when the patient is not willing or able to endure a protracted combined surgical and prosthetic session that could demand up to 3 to 4 hours of uninterrupted time in the dental chair.
- When the restoration involves a multiunit prosthesis, it should be reinforced with a cast metal bar.
- This option is also preferred when the prosthesis has more than three units or when the prosthodontist prefers to have the laboratory construct the prosthesis.



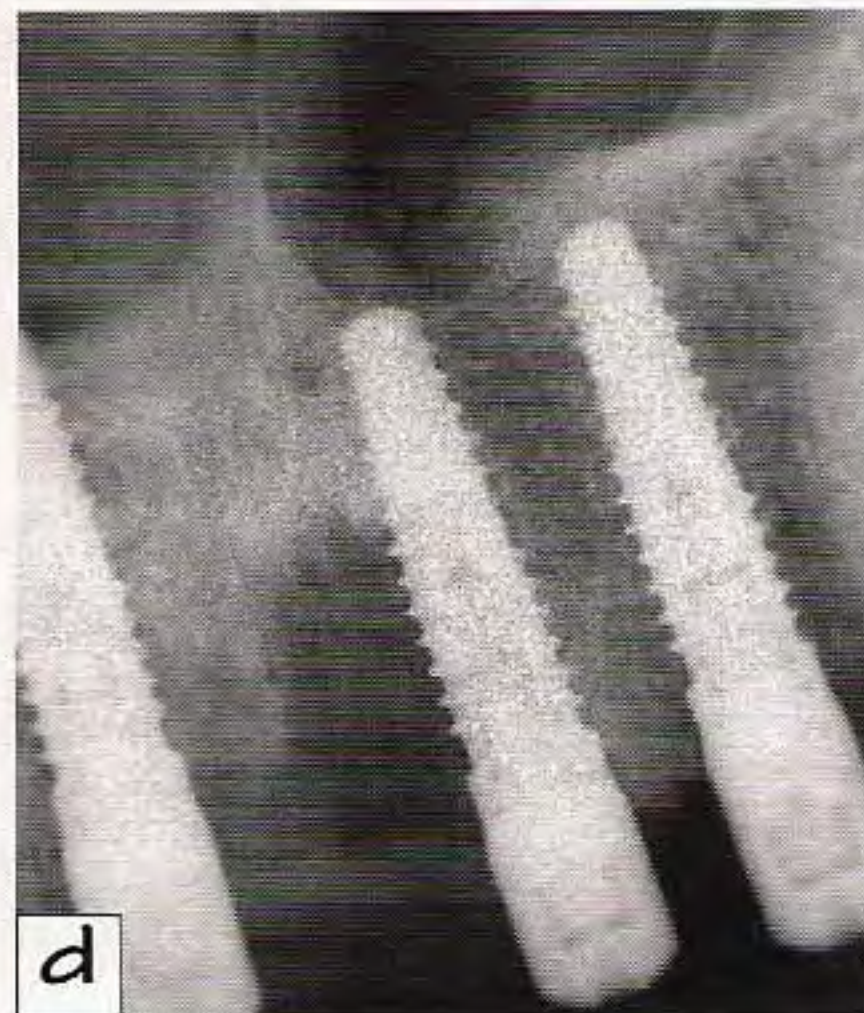
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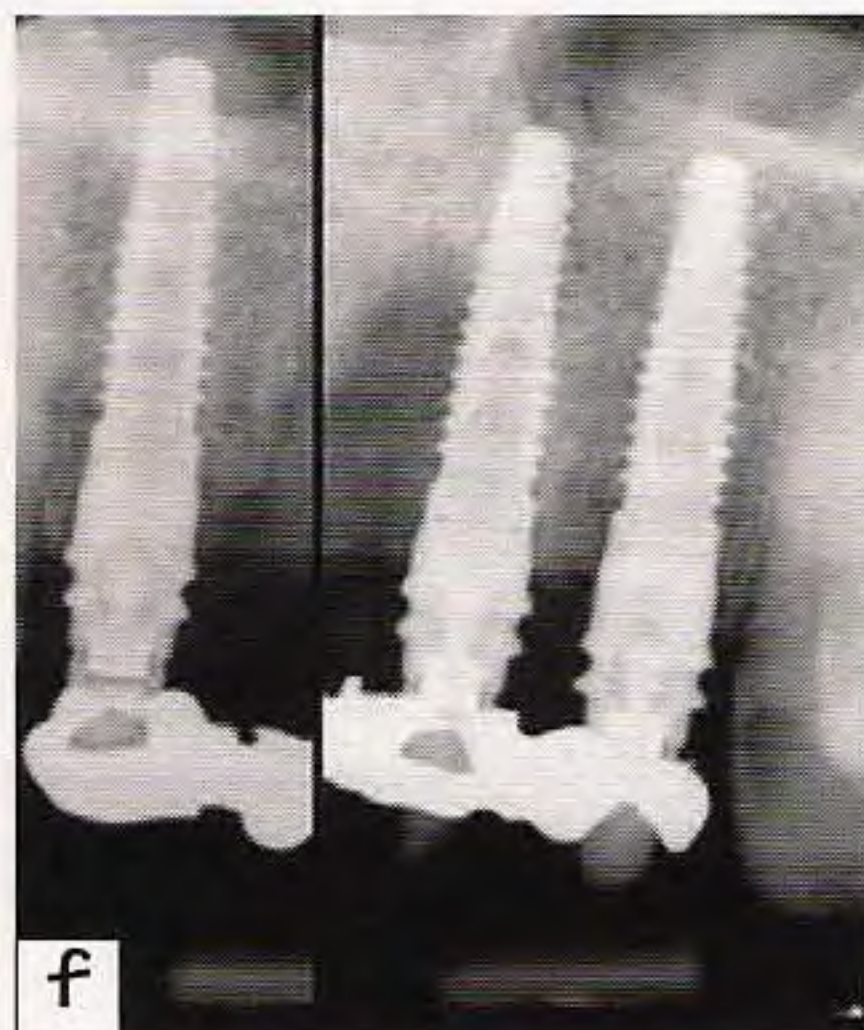
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◀ **Fig 11-35** Treatment of a patient with a thick periodontal biotype (a) Pretreatment clinical view. (b) Preoperative periapical radiograph revealing the severity of the bone loss resulting from advanced periodontal disease. (c) Postoperative clinical situation immediately after the atraumatic extraction of teeth and the placement of three implants. (d) Postoperative periapical radiograph. (e) Clinical view immediately after placement of the provisional prosthesis. The gingival margins around the prosthesis appear to be well adapted, particularly between the incisors. (f) Periapical radiographs taken immediately after cementation of the provisional prosthesis. Note the metal reinforcing bar. (g) Clinical view 1 week after cementation of the prosthesis. The recession of the gingiva around the incisors is obvious. (h) Clinical view at 3 months. With maturation of the soft tissues, the gingival margin has partially recovered from its previous pronounced recession. (Prosthesis by Dr E. Hazan and J. Binois.)

Key information for treatment option 5

Figure 11-36 summarizes the key aspects of prosthetic treatment in accordance with treatment option 5.

Technical difficulty is low

The prosthetic phase is greatly simplified because the prosthesis is made in the laboratory.

Team coordination is tight

The surgical and prosthetic phases take place one after the other. An impression is taken immediately after implant placement and then delivered to the laboratory, which uses it to make the prosthesis. The laboratory starts working immediately after the surgery. The prosthesis is delivered as soon as possible, within 1 or 2 days. All these participants must weave their separate roles into a seamless and chronologically flawless joint enterprise.

Treatment time is limited

The surgical and the prosthetic phases are not immediately consecutive. They are carried out in stages of 1 to 2 hours for the surgical phase and 1 to 1.5 hours for the prosthetic phase, which itself is divided into two sessions, one for taking the impression and one for delivering the prosthesis.

Number of implants: 1 to 4

This amount varies from one for a single crown to three or more for a prosthesis.

Esthetic requirements are high

Esthetic considerations are important for this option, except for patients who have a low smile line. The criteria for implant placement are strict (see chapter 5).

Extra costs are low

Immediate loading is considered an alternative to provisional restoration with a resin-bonded tooth-supported prosthesis. Component and laboratory costs are similar and the chair time is limited, so fees are lower for this option. In addition, the final abutments serve double duty, for both the provisional and the final prostheses.

Additional risk is moderate

Obtaining good primary stability is sometimes a problem, especially when implants are placed in extraction sites. When possible, it is desirable to splint implants with a metal-reinforced prosthesis. The esthetic risk has not yet been fully evaluated.

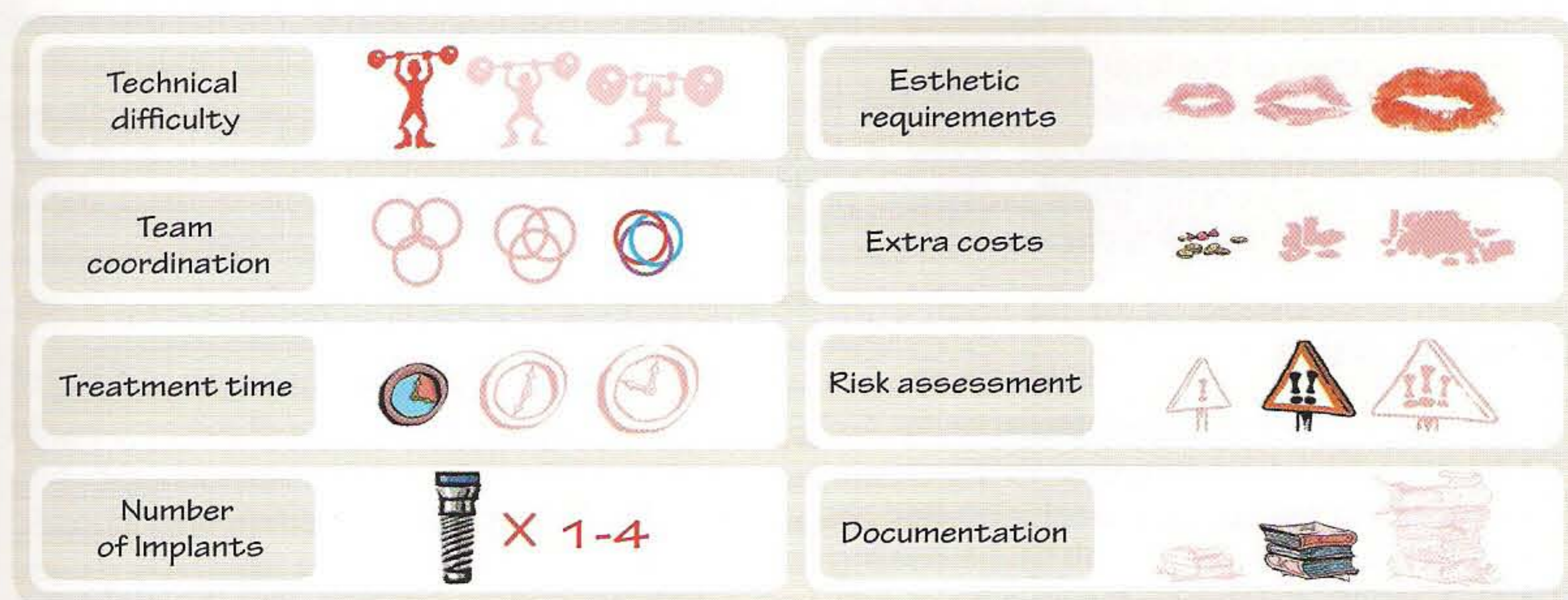
Documentation in the literature is moderate

More and more studies are being published about this indication, which is the one best suited for immediate loading.

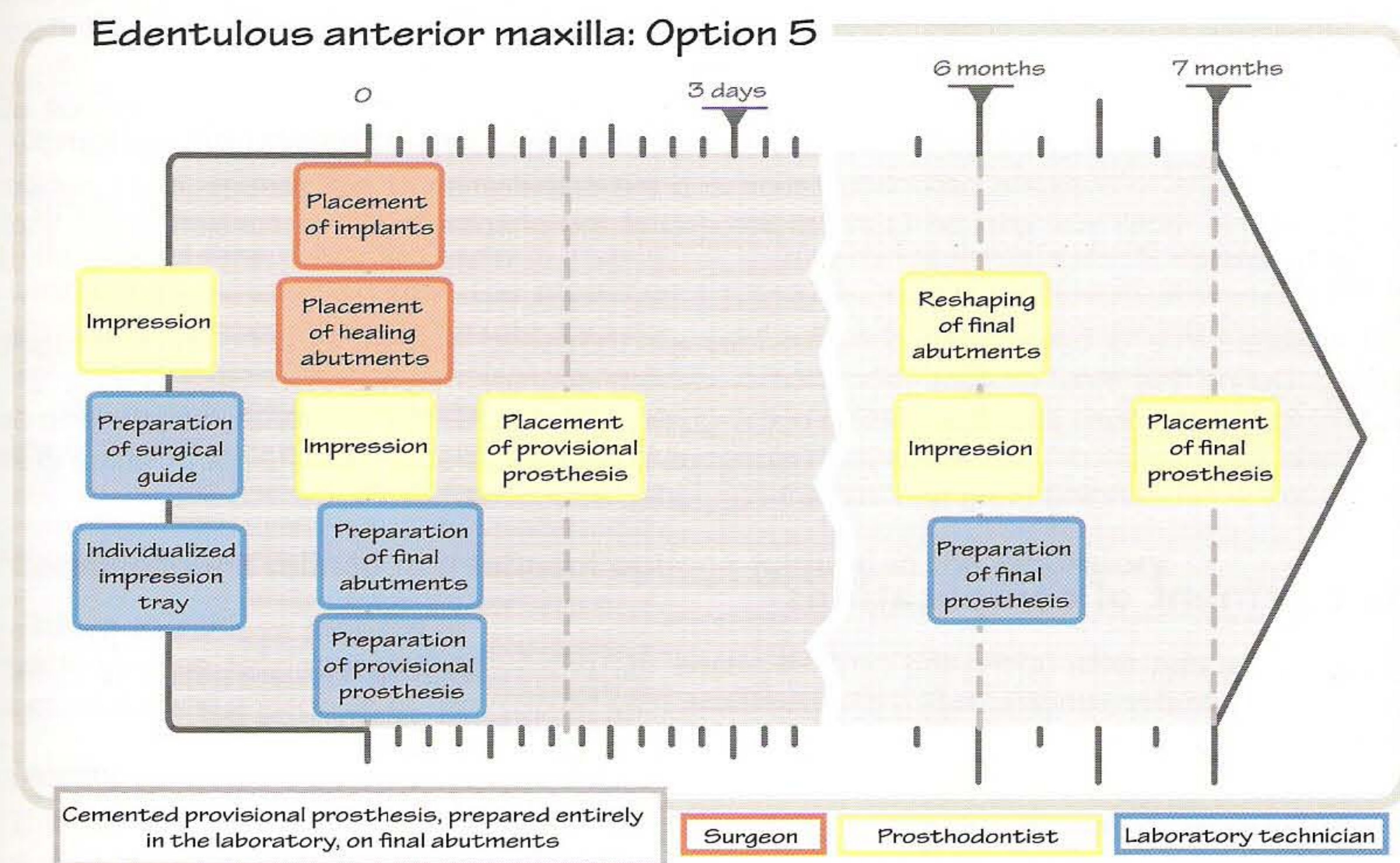
Sequence and timing of steps for treatment option 5

Figure 11-37 illustrates the treatment chronology for option 5:

- The laboratory work proceeds in two stages. Before implant placement, the laboratory makes the surgical guide and the individualized impression tray. Afterward, the laboratory constructs the prosthesis.
- Implants are placed in the usual way, according to the established rules for the procedure.
- The prosthodontist takes an impression immediately after completion of the surgery.
- The prosthetic phase begins in the next separate session, which takes place 2 to 48 hours later, depending on the location of the laboratory, its availability, and the number of units in the prosthesis.



▲ **Fig 11-36** Key information for treatment option 5.



▲ **Fig 11-37** Sequence and timing of steps for treatment option 5. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

- After 6 months of function, which also corresponds to the time it takes for the soft tissues to mature, implant stability is tested and the esthetic status of the provisional prosthesis is evaluated.
- The final prosthetic phase begins differently in option 5 than it does in treatment option 4. The abutments used for the provisional prosthesis are not unscrewed; if gingival recession has occurred, the cervical margins of the abutments will be reshaped in the mouth. The

prosthodontist takes an impression with the abutments in place and sends it to the laboratory for fabrication of the final prosthesis.

- The surgical and provisional prosthetic phases of this option with the final abutments are identical to those of treatment option 4. Only the final prosthetic phase differs; it is, in fact, identical to the conventional prosthetic procedures for placement of crowns or fixed partial prostheses on natural teeth.

Control visits

Patients are advised to eat soft foods for the first 6 to 8 weeks after the placement of the prosthesis.

Patients receive follow-up examinations:

- At 1 day to evaluate the occlusion and assess the beginning of healing.
- At 10 days to check on soft tissue healing and to remove sutures.
- At 1 month to assess the quality of soft tissue healing and to be sure that the patient is asymptomatic. It is not necessary to check implant stability either manually with percussion or with the Periotest (Medizintechnik Gulden) or Osstell (Osstell). If there is a specific reason for doing so, the prosthesis can be unscrewed at this visit. This manipulation does not interfere with bone repair but it is by no means routinely indicated. However, unseating of a cemented prosthesis is definitely contraindicated because this could exert forces that would interfere with bone repair.
- At 3 months to assess the status of the soft tissue healing and to confirm the absence of symptoms. This is also a good time to obtain a control radiograph.
- At 6 months to evaluate osseointegration and the stabilization of soft tissues. More details about this recall visit can be found at the end of the chapter in the discussion about final prostheses.

The allotted time for osseointegration coincides with the period required for bone and soft tissue healing. During this time, gingival recession of varying degrees may develop. Recession is the result of local conditions and is a function of the quality of the patient's periodontal biotype (thin or thick) and the quantity of the soft tissues. Recession is also associated with implant positioning in relation to the surrounding bone and implant-supported structures.

Management of complications

Complications can arise during the surgical phase, the prosthetic phase, or after delivery of the provisional or final prosthesis. These complications may be common to all options or specific to a given prosthetic option.

Complications during the surgical phase

Complications common to all options

Insufficient primary stability

If primary stability is insufficient (less than 45 Ncm) for a single crown, it is advisable to abandon the implementation of immediate loading with this implant. It is, however, possible to substitute a longer or larger implant for the defective one. If the replacement implant is wider, the new distances between it and the adjacent implants or the natural teeth should be carefully reassessed, as well as its new relationship to the buccal plate. The compatibility of the larger implant with the local esthetic requirements should also be verified.

Because of the limited available space, it is usually not possible to increase the number of implants for the restoration of a few missing teeth, as it would be for a completely edentulous jaw.

When primary stability is inadequate, it is possible to leave the deficient implant in place and proceed with a conventional early- or delayed-loading protocol, depending on the local conditions.

Provisionalization should proceed in the form of restorations such as a resin-bonded prosthesis or a removable partial denture.

Encroachment on the buccal plate

If the surgeon has miscalculated the thickness of the buccal bone and, while drilling, encroached on it, the immediate-loading protocol should be abandoned. The solution consists of leaving the implant in place and grafting the plate with a membrane or removing the implant. Provisionalization with a resin-bonded prosthesis or a removable partial denture can be employed.

Improper angulation or positioning of implants

When implants are improperly angulated or positioned, bone resorption of the buccal plate of bone and deterioration of the anticipated esthetic can result. When this happens, it is advisable to abandon the immediate-loading treatment plan and perform a bone graft in the affected area to restore adequate bulk to the buccal plate.

Complications during the prosthetic phase

Complications common to all treatment options

- Hemorrhage during try-in of cylinders or abutments
- Rupture of sutures during try-in of cylinders or abutments

Complication related to treatment options fulfilled at chairside

Patient fatigue

If the patient begins to show signs of impatience or fatigue, the delivery of the prosthesis can be postponed until the next day. The prosthodontist places healing abutments and dismisses the patient, who goes home to recuperate. The prosthodontist receives the rested patient on the following day to continue fabricating the prosthesis at chairside, as initially planned.

Alternatively, the prosthodontist can take an impression with the best-fitting tray available, register the occlusion with a wax bite, and send both to the laboratory for fabrication of the prosthesis. The prosthesis can then be delivered the next day or the day after in a less fatiguing session.

Complications related to treatment options fulfilled in the laboratory

Failure to achieve passive fit

This can be the result of an inaccurate impression (options 2, 4, and 5) or excessive polymerization shrinkage of the acrylic resin around the provisional cylinders (option 2).

Incomplete removal of impression material from gingiva

This complication manifests only some time after the impression has been taken; it should be suspected when the clinician observes inflammation of the gingiva.

Complications related to screw-retained prosthetic options

Excessive buccal angulation of implants

When this happens, the screw access paths will emerge on the incisal edge or the labial surface of the crowns. The prosthodontist can mask these openings with a layer of resin composite and obtain a temporary satisfactory result. If this is not possible, the retention mode will have to be changed and the prosthesis will have to be cemented.

If titanium abutments are not available in the office or in the laboratory, immediate loading should be postponed up to 72 hours. To accommodate the patient, the prosthodontist should find some provisional solution in the interim.

The screw-retained option that employs a titanium Gingihue abutment, originally devised to support a cemented prosthesis (see Fig 11-17), can be adapted for both screw-retained and cemented prostheses. This affords the prosthodontist great flexibility in preparation of the prosthesis.

Failure to achieve passive fit

This problem usually results from excessive polymerization shrinkage of the resin around the provisional cylinders.

Complication related to cemented prosthetic options

Incomplete removal of excess

If any excess cement is inadvertently left in place, it can cause irritation and gingival inflammation will appear after some delay. The removal of cement should be especially meticulous around extraction sites to prevent inflammation from occurring in this critical area.

Complications after delivery of the prosthesis

Complication common to all prosthetic treatment options

Fracture of acrylic resin teeth in provisional prosthesis

This problem has been frequently described in the literature. When it happens, the prosthodontist should check the occlusion of the prosthesis and eliminate the cause of the trauma. The laboratory can then readily repair the damage.

Complication related to treatment options fulfilled in the laboratory

- Incomplete removal of impression material from gingiva

Complications related to screw-retained prostheses

- Loosening of cylinder screws
- Loosening of abutment screws

Complications related to cemented prostheses

- Debonding of prosthesis
- Incomplete removal of excess cement

Implant failures and alternative treatments

Failure of an essential implant

When the clinician determines that an implant has become mobile, immediate action should be taken before resorption of the crestal bone takes place.

If the restoration is a single crown, the implant is removed and all fibrous tissue is cleaned from the alveolus. The implant site is drilled to allow placement of a larger and longer implant if possible, in conformity with the rules of implant placement. If a primary stability of 45 Ncm or greater is obtained, this new implant can be loaded immediately and the crown is restored to its function.

If satisfactory primary stability of the new implant cannot be obtained in that site, immediate-loading treatment should be abandoned. The failed implant is removed and the site is allowed to heal for 2 to 3 months before another implant is placed in that position. During the healing period, the prosthodontist must provide an alternative provisional restoration: a resin-bonded provisional crown or a removable partial denture, which is a less satisfactory solution.

Failure of an unessential implant

When clinicians find that an implant that is not essential to the functioning of the provisional prosthesis is mobile, it should be removed or unloaded if feasible (see chapter 8). The corresponding prosthesis site without the implant is filled with acrylic resin. The patient uses this adjusted provisional prosthesis until the final one is ready.

Final prosthetic phase

Considerations common to all treatment options

The final prosthetic phase can begin 6 months after placement of the provisional prosthesis, when maturation of soft tissues has been achieved.

Osseointegration is verified radiographically and clinically. Radiographically, osseointegration is evidenced by the absence of a dark, radiolucent area around the implant. Clinically, the implant is:

- Tested manually for mobility
- Assessed for the presence or absence of any clinical sign such as pain or local inflammation
- Tested with application of a 20-Ncm counter torque
- Assessed with the Periotest or Osstell to measure implant stability (see chapter 4)

Esthetic considerations

Final prosthesis on “provisional” abutments or cylinders

The prosthodontist determines the extent of soft tissue recession. When it is not significant, the prosthodontist can proceed with a new impression because gingival maturation has been confirmed. The final prosthesis will be constructed to conform to the new cervical parameters, with emergence profiles adjusted accordingly. If gingival recession is severe, a gingival graft should be considered.

The final prosthesis can be screw retained or cemented. The reasons for selection of one or the other have been discussed in chapter 7.

To prepare the final prosthesis, the prosthodontist removes the provisional prosthesis, takes an impression in the traditional manner on the implant necks, and sends it to the laboratory for fabrication of a ceramometal or an all-ceramic prosthesis.

Final prosthesis on “final” abutments

To avoid initiating gingival recession by repeated manipulation of the abutments, the “final” abutments are not unscrewed. If some gingival recession has occurred around the abutments, the prosthodontist adapts the cervical margins of the abutments in the mouth. An impression of the reshaped abutments is taken in conformity with accepted prosthetic principles. The final prosthesis is prepared and placed in the mouth, and the occlusion is adjusted.

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Chapter 12

TREATMENT OF THE EDENTULOUS MAXILLA

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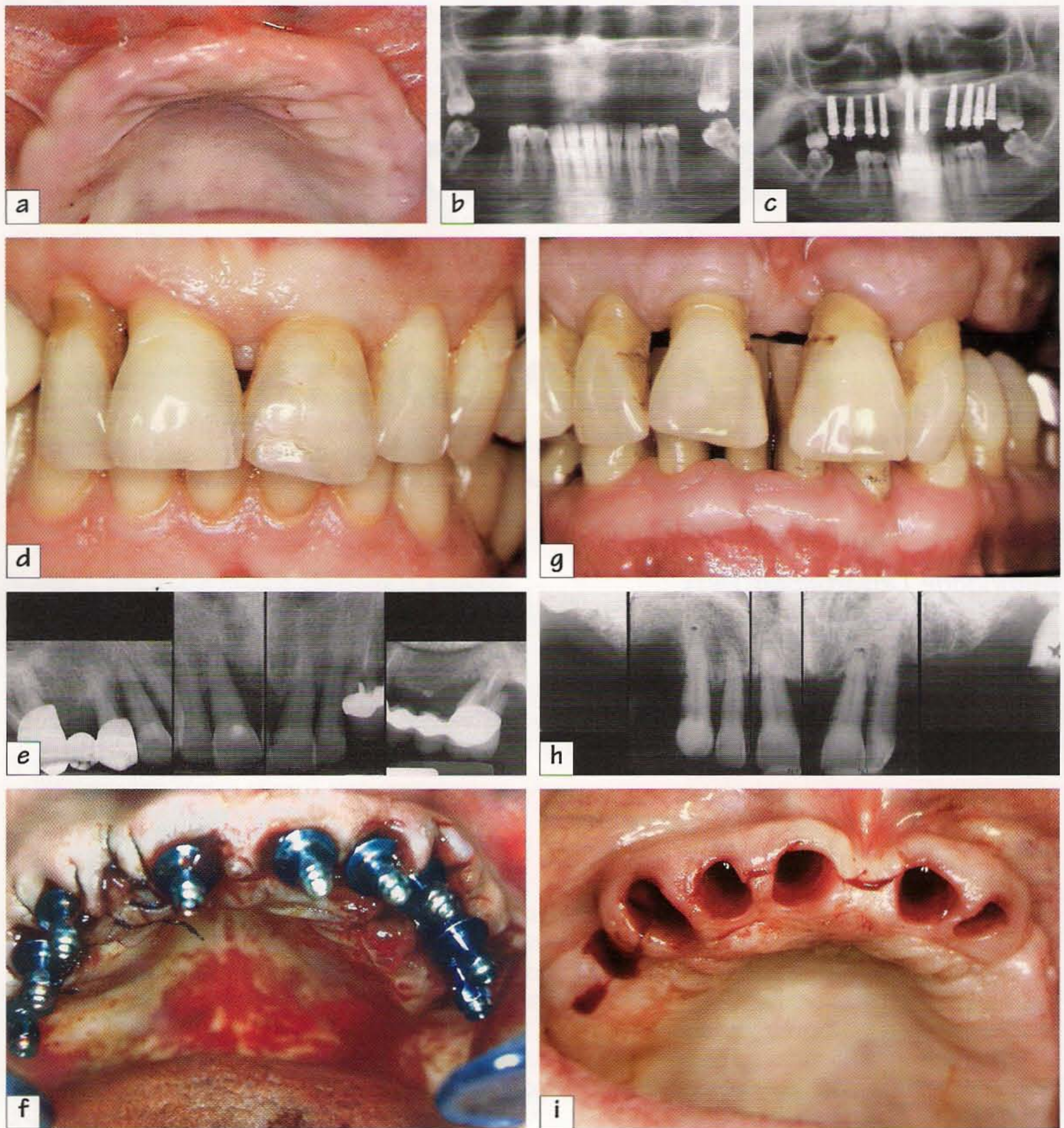
Clinicians began to treat the edentulous maxilla with immediate-loading protocols when documentation of satisfactory results obtained with immediate loading in the edentulous mandible became persuasive. They had been reluctant to undertake immediate loading in the maxilla because maxillary bone is less dense than mandibular bone and because of skepticism about the possibility of obtaining good esthetic results in the maxilla.

Today, this indication for immediate loading is one of the best documented,¹⁻²⁶ after treatment of the edentulous mandible. More studies with more than 3-year follow-up of immediate loading in the edentulous maxilla have been published.¹⁻³ A recent review article²⁷ reported data on 276 patients with 2,157 implants in a 6-month to 5-year follow-up. The average reported success rate was 98.2%, and many studies reported an implant survival rate of 100.0%; these results are similar to those obtained with conventional protocols.

Treatment of the edentulous maxilla includes:

1. Rehabilitation of the maxilla that has been edentulous for varying periods of time; all implants will be placed in healed sites (Figs 12-1a to 12-1c).
2. Rehabilitation of the maxilla that is "becoming edentulous" after extraction of all remaining hopeless teeth; all implants will be placed in extraction sites (Fig 12-1d to 12-1f) or in a combination of healed and extraction sites (Fig 12-1g to 12-1i).

The overall management of both these situations are similar. The specific characteristics and the particular difficulties associated with each indication will be specified in this chapter.



▲ **Fig 12-1** Clinical conditions included in the term *edentulous maxilla*. (a to c) Edentulous maxilla that presents only healed sites for implant placement. (a) Clinical appearance of the edentulous maxilla. (b) Preoperative panoramic radiograph. (c) Postoperative panoramic radiograph of the implants placed in healed sites. (d to f) Maxilla that is about to become edentulous and will present only extraction sites for implant placement. (d) Anterior view of maxilla before extraction of all remaining teeth. (e) Preoperative radiographs. (f) Postoperative view of the implants placed in extraction sites. (g to i) Edentulous maxilla that presents both healed and extraction sites for implant placement. (g) Anterior view of maxilla before extraction of all remaining teeth. (h) Preoperative radiographs. (i) Postoperative view. Implants will be placed in both healed sites and extraction sites.

▼ Treatment Options

The range of treatment options for the edentulous maxilla is outlined in Fig 12-2a in the form of a decision tree with successive decisions nodes. The decision tree is similar for both healed and extraction sites.

Decision nodes

First decision node

The first decision involves a choice between two prosthetic options: (1) a screw-retained prosthesis or (2) a cemented prosthesis. Clinicians may base their decisions on personal preference, but also have to take into consideration local factors such as the amount of bone resorption and the divergence between the anterior and posterior segments.

A screw-retained prosthesis can be considered only if the screw access holes will emerge on the palatal anterior and occlusal posterior surfaces of the crowns.

Screw-retained provisional option

When the "screw-retained" option is chosen on the decision tree, the prosthodontist continues with additional choices.

Second decision node

The clinician must choose between (1) laboratory fabrication of a prosthesis from an impression taken immediately after implant placement or (2) use of the conversion prosthesis technique to transform a removable denture into a fixed prosthesis.

Third decision node

After the completion of osseointegration and maturation of the soft tissues, the clinician must determine if the final prosthesis should be (1) screw retained or (2) cemented.

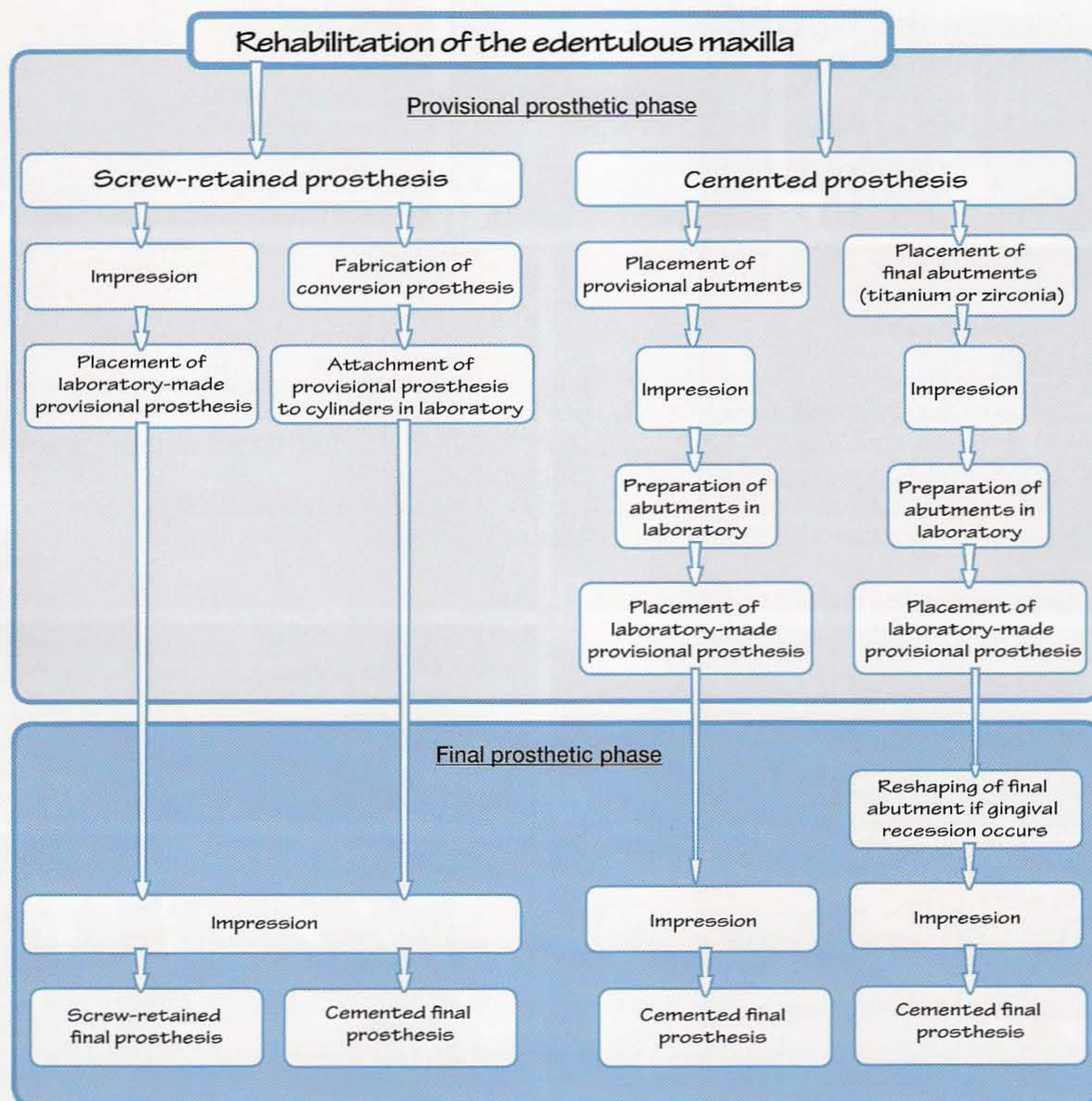
Cemented provisional option

If the option "cemented prosthesis" is selected, the clinician continues on the decision tree with a further choice.

Second decision node

The clinician must choose between (1) placement of provisional abutments that will be replaced when the final prosthesis is placed or (2) placement of final abutments that are positioned immediately after implant surgery. For esthetic reasons, these abutments will not be unscrewed at any time and will be part of the final prosthesis.

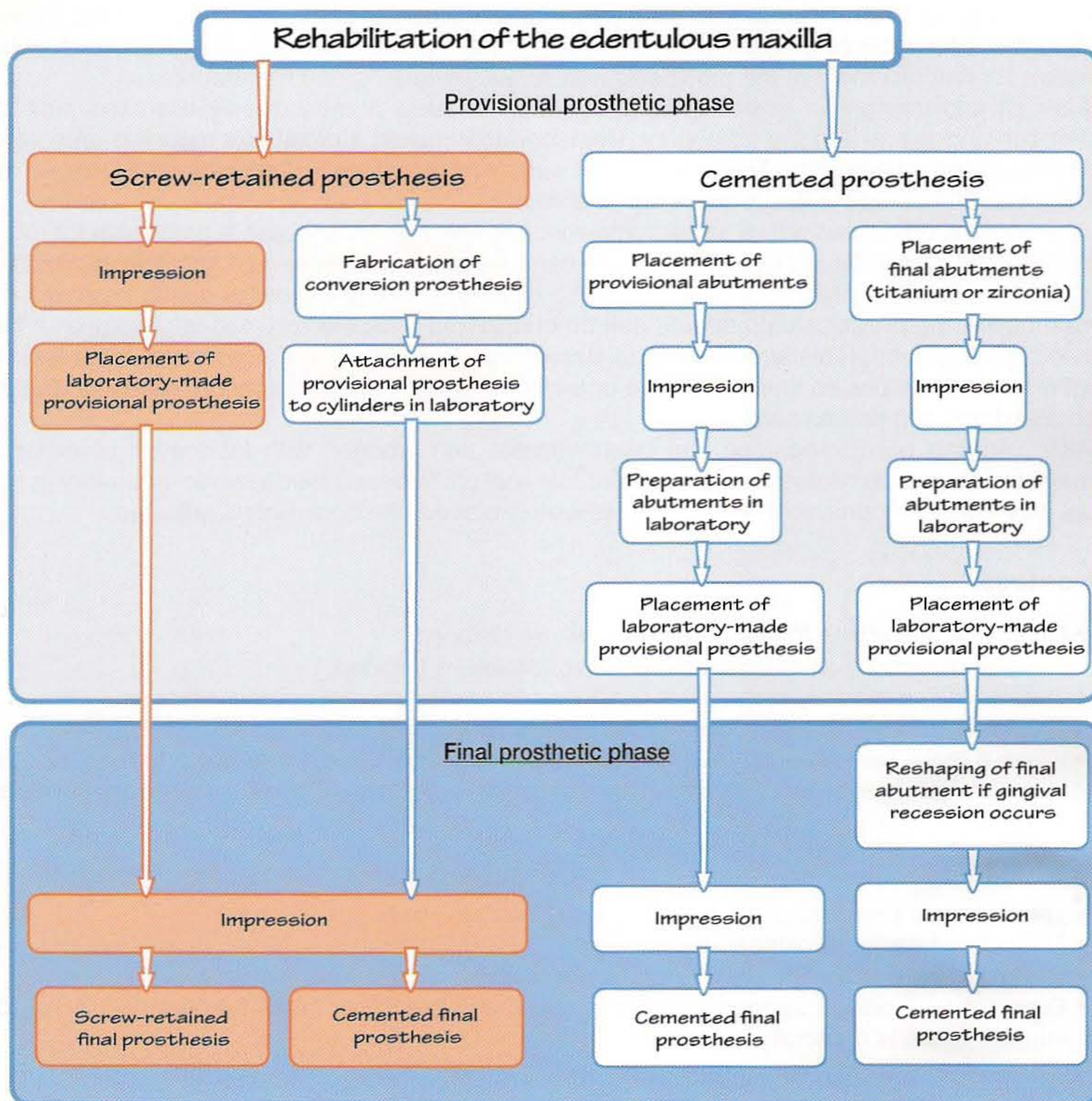
After 6 months of function, which corresponds to the time required for soft tissue maturation, the clinician evaluates implant stability before beginning fabrication of the final prosthesis. The provisional abutments, which were placed after surgery, are unscrewed to take an impression from which the laboratory will make a final cemented prosthesis.



▲ **Fig 12-2a** Decision tree showing all treatment options available to rehabilitate the edentulous maxilla. These options are common to healed and extraction sites.

Treatment options for rehabilitation of the edentulous maxilla

- Option 1:** A screw-retained provisional prosthesis is placed within 48 to 72 hours after surgery; the prosthesis is fabricated entirely in the laboratory.
- Option 2:** A screw-retained provisional prosthesis is placed within 24 hours after surgery; the removable denture is attached to provisional cylinders in the laboratory, according to the conversion prosthesis technique.
- Option 3:** A cemented provisional prosthesis is placed within 72 hours after surgery; provisional abutments and the prosthesis are prepared in the laboratory.
- Option 4:** A cemented provisional prosthesis is placed within 72 hours after surgery; final abutments and the prosthesis are prepared in the laboratory.



▲ **Fig 12-2b** Treatment option to rehabilitate the edentulous maxilla when a screw-retained provisional prosthesis is preferred. The sequence of steps is indicated in red. With this option, the final prosthesis can be either screw retained or cemented.

Treatment option I

Screw-retained provisional prosthesis placed within 48 to 72 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

This option (Fig 12-2b) is chosen when:

- A screw-retained prosthesis is preferred to a cemented prosthesis.
- The implants axes are compatible with palatal anterior and occlusal posterior screw access paths.
- One of the principal determinants of treatment is to provide a durable and fracture-resistant prosthesis; in such cases, the provisional prosthesis is constructed on a metal framework.

In this treatment option, an acrylic resin screw-retained denture, with or without a metal framework, is made for patients with moderate resorption of the maxillary ridge. Sufficient space must be available for reinforcement of the prosthesis with acrylic resin or for the framework.

After all implants are in position, the prosthodontist takes a meticulously executed pick-up impression and sends it to the laboratory. The laboratory makes a prosthesis mounted on screw-retained provisional cylinders. The patient is left without maxillary teeth during the time required for the laboratory to complete this process, up to 3 days.

A provisional prosthesis with a metal framework can serve as a serviceable prosthesis for more than 6 months, under the right conditions. This can be especially appropriate for patients who live at a distance from the practitioner's office or who have little time to devote to dental treatment. In certain cases, the provisional prosthesis can be considered a satisfactory mid-term solution if the esthetic result is acceptable after soft tissue stabilization. The provisional phase lasts for at least 6 months for implants placed in either healed or extraction sites. During this period, osseointegration is obtained and soft tissues stabilize.

After verifying osseointegration, the prosthodontist can proceed with fabrication of either a screw-retained or a cemented final prosthesis. The final prosthesis is made by the laboratory in the usual way, from an impression. After the prosthesis is placed, the occlusion is adjusted.

Advantages

- Chair time and stress for the prosthodontist are reduced.
- The use of cement, which can irritate the soft tissue, is avoided.
- The clinician can easily remove the prosthesis to assess implant osseointegration.
- The fee can be reduced because of the reduced chair time for the prosthodontist.
- When a metal framework is used, the provisional prosthesis is more resistant to fracture. It is reliable for a longer period than acrylic resin dentures, even those reinforced with a cast metal bar.

Disadvantages

- The patient is deprived of the maxillary teeth for 1 to 3 days after surgery.
- The screw-retained prosthesis may loosen.
- When a metal framework is used, the fees increase.
- Even with the added strength provided by a more expensive metal framework, the risk of implant failure is not totally eliminated.

Treatment tip:

- This option should be chosen when a screw-retained prosthesis is preferred.
- It is recommended that the acrylic resin prosthesis be reinforced with a cast metal bar.
- When a metal framework is used, the prosthodontist should select a laboratory that is experienced in precise and rapid fabrication of such prostheses.

Treatment option 2

Screw-retained provisional prosthesis placed within 24 hours after surgery; the removable denture is attached to provisional cylinders in the laboratory, according to the denture conversion technique.

This option (Fig 12-2c) is chosen when:

- Ridge resorption is advanced and support of the soft tissues of the lip and jaw is required.
- The implants' axes are compatible with palatal anterior and occlusal posterior screw access paths.

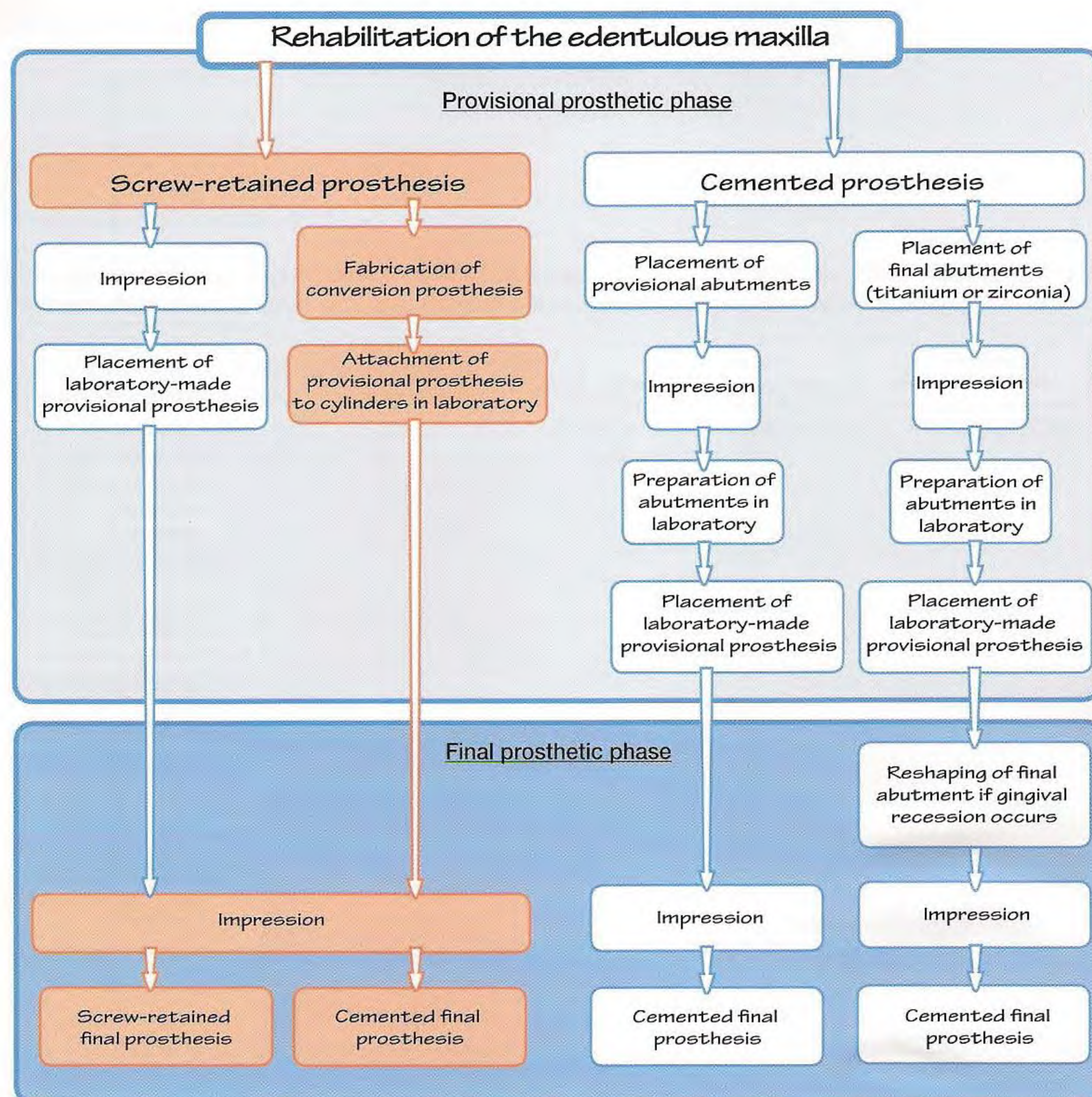
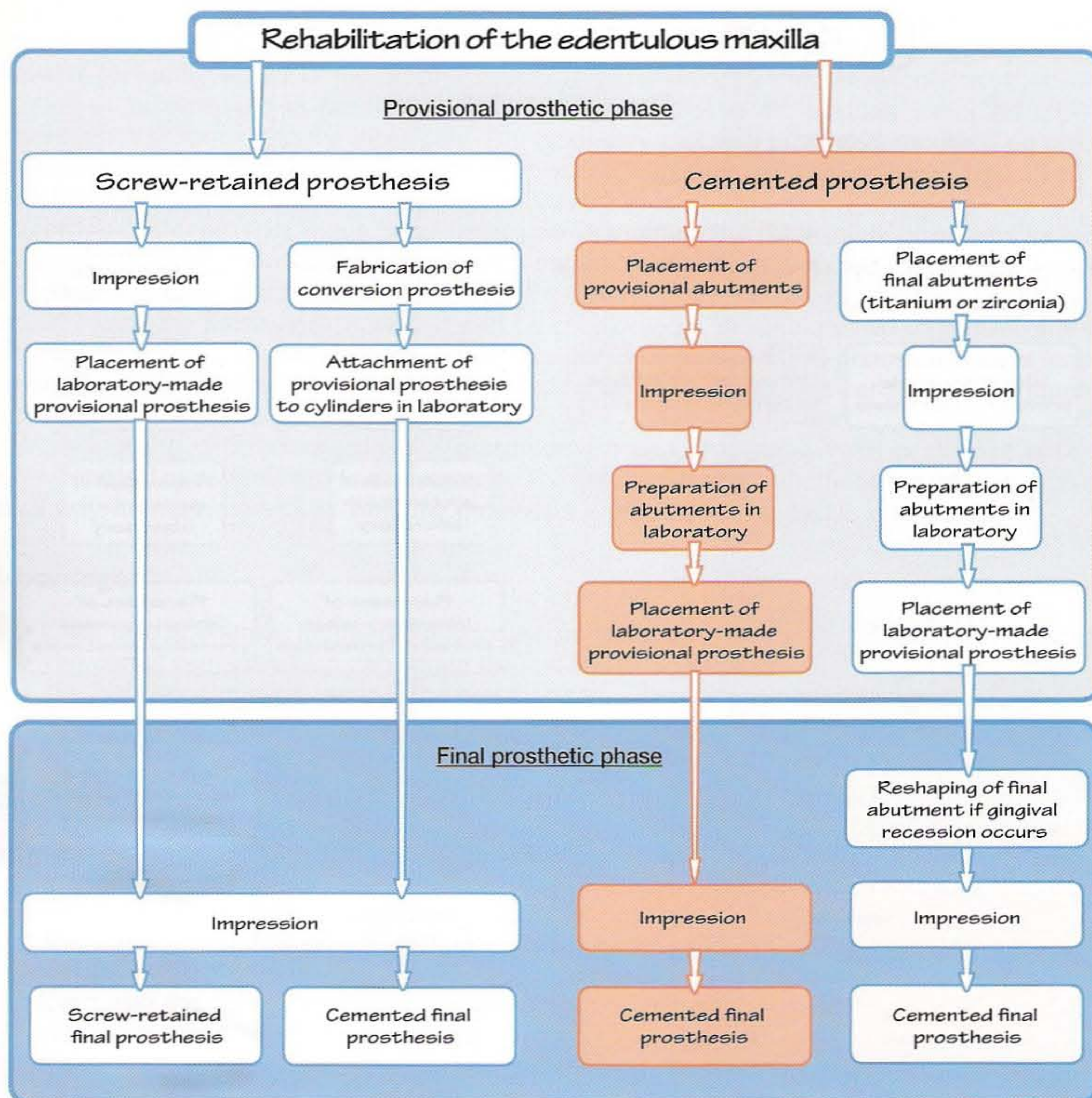


Fig 12-2c Treatment option to rehabilitate the edentulous maxilla when a screw-retained prosthesis with soft tissue support is preferred. The sequence of steps is indicated in red. With this option, the final prosthesis can be either screw retained or cemented.

Option 2 involves application of the conversion prosthesis protocol to the maxilla. A removable denture is transformed into a fixed prosthesis by the laboratory and not by the prosthodontist working at chairside. To accomplish this, the prosthodontist takes an impression of the transgingival abutments and a wax bite of the interocclusal relationship and sends them to the laboratory. The laboratory technician hollows the removable denture, attaches it to the provisory cylinders, and completes the finishing details.

The patient receives the fixed provisional prosthesis within 24 hours. Two options for delivery of the prosthesis are available. In the first, the laboratory is an integral part of the prosthodontist's office or is located near it. The patient can rest in the waiting room while the laboratory accomplishes the denture conversion process. Treatment is completed in a single day, in two sessions of reasonable length. In the first, the implants are placed and an impression is taken in a 2- to 3-hour



▲ **Fig 12-2d** Treatment option to rehabilitate the edentulous maxilla when a prosthesis cemented on provisional abutments is preferred. The sequence of steps is indicated in red. With this option, the final prosthesis is cemented.

session. In the second, which lasts for 1 to 2 hours, the prosthodontist attaches the screw-retained prosthesis to the implants and the occlusion is adjusted.

In the second variant, the laboratory is located some distance from the prosthodontist's office. Delivery of the prosthesis is usually postponed until the next day or even later. The delay offers the advantage of giving the patient time to recuperate after surgery.

Advantages

- The soft tissues of the lip and jaw are supported.
- Chair time and stress for the prosthodontist are reduced.
- The use of cement, which can irritate the soft tissues, is avoided.
- The clinician can easily remove the prosthesis to assess implant osseointegration.
- The fee can be reduced because there is less chair time for the prosthodontist.

Disadvantages

- The patient is deprived of the maxillary teeth for several hours or 1 or 2 days after surgery.
- If the wax bite is inaccurate, the prosthetic phase may have to be repeated.
- The screw-retained prosthesis may loosen.

Treatment option 3

Cemented provisional prosthesis, placed within 72 hours after surgery; provisional abutments and the prosthesis are prepared in the laboratory.

This option (Fig 12-2d) is chosen when:

- A cemented prosthesis is preferred to a screw-retained prosthesis.
- It is necessary to compensate for imperfect parallelism of the implants. The laboratory trims the abutments and fabricates a cemented prosthesis.
- The periodontal biotype of the patient is thick.

In this protocol, the prosthodontist takes an impression immediately after surgery and sends it to the laboratory. The titanium abutments and the metal-reinforced acrylic resin prosthesis are prepared within 3 days. During this time, the patient has no maxillary restoration.

Advantages

- Chair time and stress for the prosthodontist are reduced.
- The fee can be reduced because of chair time for the prosthodontist.
- When a metal framework is used, the provisional prosthesis is more resistant to fracture. It is reliable for a longer period than acrylic resin dentures, even those reinforced with a cast metal bar.

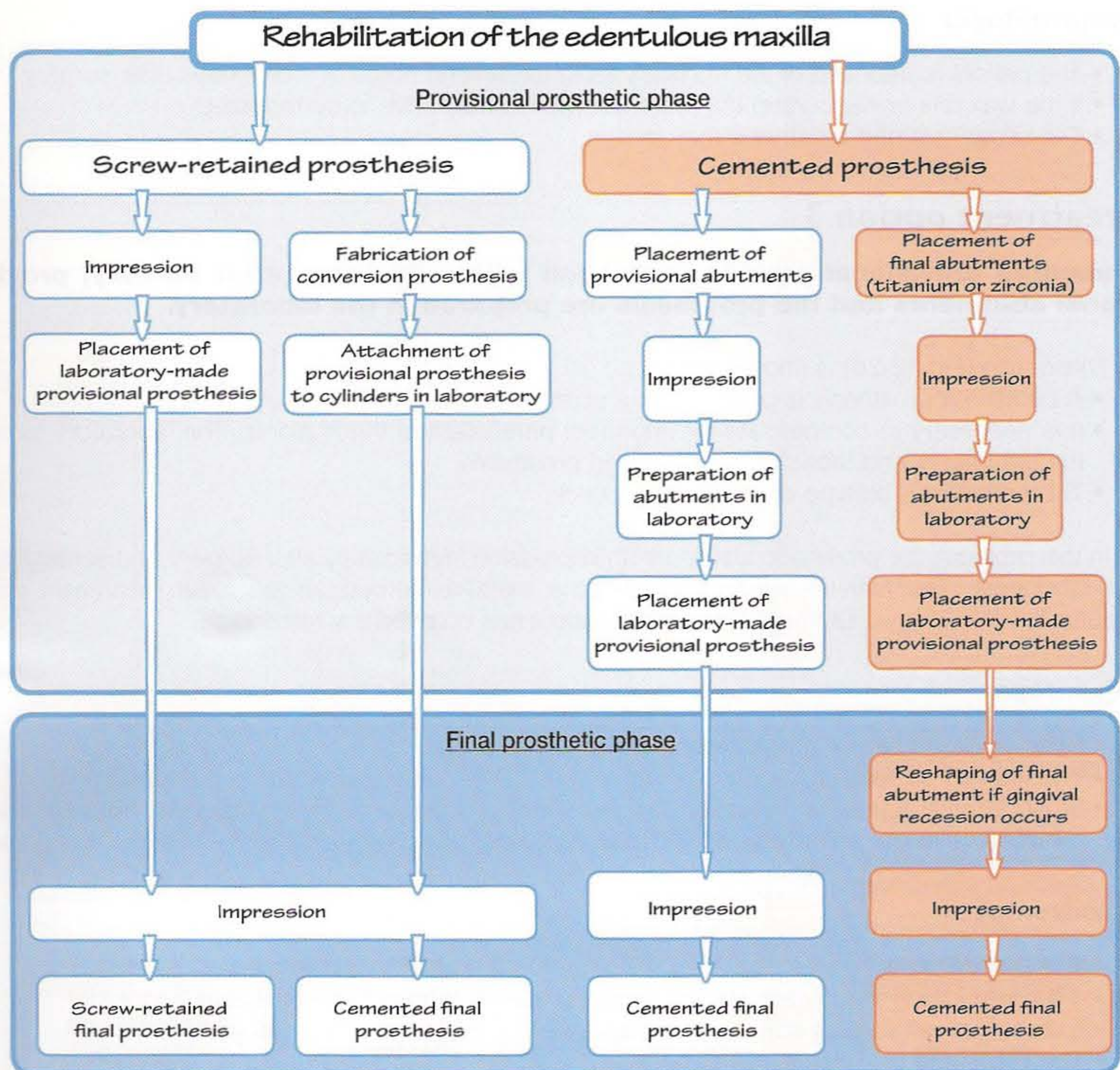
Disadvantages

- The patient is deprived of maxillary teeth for 1 to 3 days after surgery.
- If the wax bite is inaccurate, the prosthetic phase may have to be repeated.
- Excess cement can be trapped in the gingiva.
- The cemented prosthesis may debond.
- When a metal framework is used, costs are increased.
- Even with the added strength afforded by a more expensive metal framework, the risk of implant failure is not totally eliminated.

Treatment tips:

- This option should be chosen when a cemented prosthesis is preferred.
- It is recommended that the acrylic resin prosthesis be reinforced with a cast metal bar.
- When a metal framework is used, the prosthodontist should select a laboratory that is experienced in the precise and rapid fabrication of such prostheses.





▲ **Fig 12-2e** Treatment option to rehabilitate the edentulous maxilla when a cemented provisional prosthesis is preferred and when the principal determinant of treatment is good esthetics for the patient with a thin periodontal biotype. The sequence of steps is indicated in red. The final prosthesis is cemented.

Treatment option 4

Cemented provisional prosthesis placed within 72 hours after surgery; final abutments and the prosthesis are prepared in the laboratory.

This option (Fig 12-2e) is chosen when:

- The principal determinant of treatment is esthetics for a patient with a thin periodontal biotype. With this approach the fixed prosthesis can be delivered within 3 days.
- A cemented prosthesis is preferred to a screw-retained prosthesis.

In this protocol, the prosthodontist takes an impression immediately after surgery and sends it to the laboratory. The abutments and the metal-reinforced acrylic resin prosthesis are prepared within 3 days. These abutments, made of titanium or zirconia, will serve as final abutments; they will not

be unscrewed even in the final prosthetic phase. If they have to be reshaped because of gingival recession, the prosthodontist will perform the task in the patient's mouth before taking the final impression. The laboratory will receive the impression and fabricate the final prosthesis.

Advantages

- This protocol is the one best suited for rehabilitation of the edentulous maxilla of a patient with a thin periodontal biotype.
- Chair time and stress for the prosthodontist are reduced.
- The fee can be reduced because only one set of abutments, the final one, is fabricated.
- When a metal framework is used, the provisional prosthesis is more resistant to fracture. It is reliable for a longer period than acrylic resin dentures, even those reinforced with a cast metal bar.

Disadvantages

- The patient is deprived of maxillary teeth for 1 to 3 days after surgery.
- If the wax bite is inaccurate, the prosthetic phase may have to be repeated.
- Excess cement can be trapped in the gingiva.
- The cemented prosthesis may debond.
- When a metal framework is used, costs are increased.
- Even with the added strength afforded by a more expensive metal framework, the risk of implant failure is not totally eliminated.

Treatment tips:

- This option should be chosen for the patient with a thin biotype when a cemented prosthesis is applicable.
- It is recommended that the acrylic resin prosthesis be reinforced with a cast metal bar.
- When a metal is used, the prosthodontist should select a laboratory that is experienced in precise and rapid fabrication of these prostheses.

▼ Step-by-Step Guidelines for Immediate-Loading Treatment of the Edentulous Maxilla

Indications

Available bone height at the implant site: > 11.5 mm

Available bone width at the implant site: > 6 mm

Bone quality: dense or normal (types 1 to 3)

Number of implants: 8 to 10 implants

Insertion torque of each implant: ≥ 35 Ncm

Contraindications

- Inadequate primary stability; in this case, the immediate-loading protocol must be discontinued.
- Patients who exhibit bruxism are not good candidates for immediate loading.

Specific considerations for treatment of the edentulous maxilla

Surgical considerations

- Precise three-dimensional (3D) implant positioning is crucial in sites where esthetic considerations prevail (see chapter 5).
- Efforts are required to obtain good primary stability in sites of limited bone quality.
- For prospective screw-retained prostheses, the surgeon must ensure that the implant axis will be compatible with a palatal screw access path in the anterior segment and an occlusal path in the posterior segment (options 1 and 2).

Prosthetic considerations

- The prosthesis must be prepared with balanced occlusion.
- Patience and meticulous attention to detail are essential in impression procedures.
- The prosthesis must be prepared with emergence profiles that provide proper guidance to the soft tissues during healing and maturation.
- The prosthodontist and the patient must be aware that soft tissues may not always react as anticipated; achievement of the desired esthetic result may not always be possible.
- All excess cement must be meticulously removed from around a cemented prosthesis (options 3 and 4).

Surgical phase

The treatment options and the prosthetic phase for the edentulous maxilla and the maxilla that will be edentulous after extraction of all remaining teeth are identical; only the surgical phase differs. Therefore, in the remainder of the chapter, several different surgical situations will be presented, but only one case will be presented for each prosthetic option.

Replacement of the complete dentition in maxillary healed sites

Presurgical preparation

Clinical examination

- Determination of the smile line
- Assessment of the height and width of the alveolar ridge
- Determination of the extent of bone resorption
- Determination of the angulation between the anterior and posterior segments

Radiographic examination

The height and width of the available bone are determined from panoramic radiographs and computerized tomography (CT) scans. The CT scan is useful for determining whether the ridge anatomy will lend itself to implant placement without presenting any particular difficulties and for precise localization of any concavities and bony defects in the arch.

Immediate loading should be conducted only in optimal sites, so that the clinician can concentrate on the proper execution of the prosthetic phase. Relatively minor errors in assessment of the available osseous envelope that would have little or no impact on a traditional protocol could prove fatal to an immediate-loading protocol. For example, it may be impossible to achieve a primary stability of 35 Ncm or more following encroachment on the buccal plate.

Study casts: Preparation of the surgical guide

The surgical guide is restrictive if the surgeon has to conform to strict placement rules. In the absence of esthetic requirements or when implants are placed in sites with advanced resorption, the surgical guide does not have to be restrictive.

Surgical phase

Placement of implants

Selection of implant design and implant number.

1. *Implant design.* For this indication in the maxilla, it is best to select implants that are likely to achieve good primary stability and that will promise the best possible esthetic result. Conical implants or wide-neck implants that are compatible with the platform-switching protocol increase clinical stability especially in areas of poor or even normal bone quality. When it is necessary to pay particular attention to esthetics, the concept of platform switching should be applied (see chapter 6).
2. *Number of implants.* The number of implants can vary between 8 and 10. Some authors have reported placing prostheses on 6 implants,^{19,20} but the authors prefer to use more implants and ensure good stability of the maxillary prosthesis because maxillary bone is of poorer quality than is mandibular bone.

Preparation of osseous sites. The surgeon makes an incision and raises a flap to obtain a good view of the ridge anatomy. Implants are then placed along the arc of a circle, where the most distal implants correspond to the distal limits of the prosthesis. The anterior implants are placed first, then the most distal implants, and finally the implants between the two extremes.

The anterior implants are positioned to support the central incisor teeth of the prosthesis. Implants should be placed more than 3 mm apart to preserve the interimplant crest and provide the best possible support for the interincisal papilla.

Because of the need for at least a 3-mm space between implants, no implant is placed at the lateral incisors sites. The use of pontics is an effective solution to ensure the best esthetic in this area. Other clinicians may prefer to place implants in the lateral incisor sites and leave them submerged as “sleeping” implants to preserve the bone level over the long term (see Figs 12-25 to 12-27).

Implants can usually be placed in the canine area and in posterior zones while maintaining a minimum distance between implants. Security implants, which are not immediately loaded but can, if needed, replace the function of failed implants, are preferably placed in the distal segment because the stresses there are greater. A security implant can be placed as the most distal implant; however, it then limits the distal extent of the provisional prosthesis. Alternatively, the security implant can be placed just mesial to the most distal implant, which allows the prosthesis to achieve maximum length. Depending on the clinical situation, security implants may or may not be incorporated in the final prosthesis.

Drilling sequence. The drilling sequence is carried out in the usual way or the implant bed is slightly underprepared because bone quality is routinely normal or spongy; only rarely is it dense.

3D implant positioning. This step is determined by the retention type, either cemented or screw retained. The surgical guide, made from a duplicate of the waxup, is indispensable and will either be restrictive or nonrestrictive. A restrictive guide contains elongated tubes that will precisely control the mesiodistal and buccolingual axes of the implants. Only the coronapical axis will be left to the discretion of the surgeon. A nonrestrictive guide dictates only the mesiodistal axis of the implants and leaves the buccolingual and coronapical axes to the discretion of the surgeon. The extent to which the implants can be inclined buccally is limited by the exterior envelope of the teeth. The axes of the implants must emerge on the anterior palatal and posterior occlusal surfaces of the prosthetic teeth.

1. *Mesiodistal axis.* This axis is perpendicular to the crown it supports. It is indicated by the surgical guide.
2. *Buccopalatal axis.* The buccopalatal axis of the implant must conform to the 3D requirements described in chapter 5. In the anterior segment, the distance between the external implant edge and the rim of the buccal plate should be:
 - At least 1 mm when there are no special esthetic demands for management of soft tissues
 - At least 2 mm when good esthetic management of soft tissues is required
3. *Coronapical axis.* The implant is positioned level with the crest when there is no special esthetic requirement. However, this position still must be compatible with development of a

correct emergence profile of the crown it supports. The implant is positioned 1 to 2 mm subcrestally when there are special esthetic requirements.

Primary stability. The insertion torque must be at least 35 Ncm for all implants. The motor, adjusted at 35 Ncm, should stall before final seating of the implant is completed. This is particularly important for the most distal implants, which have to withstand the greatest biomechanical stress.

Use of bone profiler. It is essential to finish preparing the site with this instrument because it ensures complete seating of the abutment on the implant neck.

Placement of healing or transgingival abutments. Placement of the transgingival abutments constitutes the beginning of the prosthetic phase, but placement takes place, for logistical reasons, during surgery just before suturing.

1. If the prosthesis is screw retained, immediate occlusal loading (IOL) or conical abutments can be screwed in the implants to elevate the prosthetic working plane to the desired level. For the conversion prosthesis procedure, the prosthodontist selects the transgingival IOL abutment height, from 2 to 7 mm, with either internal or external connections. For esthetic reasons, the abutment-prosthesis junction is subgingival and not supragingival, which is permissible for a mandibular prosthesis. Healing caps must be placed on the transgingival abutments to stabilize the gingiva, even if the patient is just moving from the surgical treatment site to the prosthetic treatment site. They prevent the gingiva from collapsing during the time required for fabrication of the prosthesis.
2. If the prosthesis is cemented, healing abutments are screwed in the implants. The abutment height depends on the gingival thickness and the subcrestal position of the implant. It is best for the abutments to extend beyond the gingiva and the clot that has formed. They will be easier to manipulate during the prosthetic phase, which begins in a few hours with impression taking and continues a few days later with delivery of the provisional prosthesis.

Suturing. The surgeon places the sutures around the healing caps or the healing abutments.

Control radiograph. A radiograph is taken to assess the accuracy of implant placement. However, it can be omitted if a radiograph is scheduled to be taken later by the same clinician following placement of implant copings on the external hex implants.

Transition from surgical treatment site to prosthetic treatment site. The transition from the surgical treatment site to the prosthetic treatment site should be planned in advance to avoid any misunderstandings and to ensure that the patient experiences a seamless transition from one specialist to the other.

The prosthetic phase will be described in detail after description of the surgical phase for implants placed in extraction sites.

Replacement of the complete dentition in maxillary extraction sites

Presurgical preparation

Clinical examination

- Determination of the smile line
- Assessment of the height and width of the alveolar ridge
- Determination of the extent of bone resorption
- Determination of the angulation between the anterior and posterior segments

Radiographic examination

The height and width of the available bone are determined using a panoramic radiograph and CT scan. When there are remaining teeth in the maxilla, the CT scan is particularly useful for:

- Determining the amount of available buccal and palatal bone around the teeth that are scheduled for extraction
- Determining whether the ridge anatomy will pose any particular difficulties during implant placement
- Locating concavities and bony defects in the arch with precision

It is desirable that immediate loading be conducted only in optimal sites so that there are no complications to interfere with or distract from proper execution of the prosthetic phase. Relatively minor errors in assessment of the available osseous envelope that would have little or no impact on a traditional protocol could prove fatal to an immediate-loading protocol.

Study casts: Preparation of a surgical guide

The surgical guide is often nonrestrictive; this allows the surgeon to decide where implants are best placed in regions that have been subjected to advanced periodontal bone loss.

Surgical phase

Extraction of teeth

Before the surgical intervention, the remaining teeth are carefully cleaned and all tartar is removed. If necessary, the patient follows a course of antibiotic therapy for 2 to 3 days before surgery. Sometimes, one or two teeth in the middle of the arch are salvageable but it is best to extract them to treat the entire maxilla with a complete-arch prosthesis. The surgeon performs the extractions atraumatically to preserve the buccal plate as much as possible.

Placement of implants

Selection of implants. As with healed sites, the surgeon should select implants that are likely to achieve good primary stability and that will promise the best possible esthetic result. Conical implants or wide-neck implants with or without platform switching fill the alveoli better and increase primary stability. If particular attention has to be paid to esthetics, the platform-switching technique can be employed (see chapter 6).

Preparation of osseous sites. At the extraction site, it is not essential to raise a flap to place the implants because access can be obtained directly through the alveolus. Flaps are required to allow precise localization of osseous landmarks when:

- Bone loss has resulted from periodontal disease.
- The CT scan has revealed the presence of bone concavities.
- Extensive gaps around the placed implants will have to be filled with autologous bone or bone substitutes.

Drilling sequence. The drilling sequence is carried out in the usual way if bone quality is normal (type 2 or 3). If the bone is of poor quality, the implant bed is underprepared. The incisal sites are prepared first, then the most distal sites, and the sites between are prepared last.

3D implant positioning. This step is determined by the retention type, either cemented or screw-retained. The surgical guide, made from a duplicate of the waxup, is indispensable. In the regions where teeth are extracted it does not need to be especially restrictive because the alveoli of the extracted teeth provide guidance. The global envelope of the prosthesis should be carefully pre-determined, but the buccopalatal inclination and the coronoapical position are left to the surgeon's discretion.

1. *Mesiodistal axis.* The mesiodistal axis of the implants is perpendicular to the crown it supports. It is indicated by the surgical guide.
2. *Buccopalatal axis.* The buccopalatal axis will depend on whether the site is anterior or posterior. In the anterior region, the implant axis does not correspond to the axis of the tooth

(see chapter 5). The implant is inclined palatally about 5 degrees, with the aim of retaining a distance of at least 2 mm between the implant edge and the external rim of the buccal plate. Implant placement has been detailed in chapter 11 in the description of single-tooth replacement. Any buccal gap greater than 1.5 mm must be filled with autogenous bone or bone substitute material. In the premolar and molar areas, implants are placed in the center of the alveolus of the extraction site.

3. *Coronoapical axis*. Coronoapical position is level with the crest when there are no special esthetic considerations. The implant is placed 1 to 2 mm subcrestally when there are special esthetic requirements.

When no flap is raised, the surgeon works without visual access to the osseous structures. In this situation, use of a graduated implant carrier is indispensable. The carrier indicates when the implant neck is located 3 to 4 mm below the gingival margin.

Primary stability. The insertion torque must be at least 35 Ncm for all implants and particularly for the most anteriorly and posteriorly located implants.

Use of bone profiler. It is essential to finish preparation of the site with this instrument, which ensures complete seating of the abutment on the implant neck, except when a platform-switching technique is used.

Placement of healing or transgingival abutments.

1. If the prosthesis is screw retained, the transgingival IOL or healing abutments are screwed into the implants, depending on the level of the prosthetic working plane. For the conversion prosthesis procedure, the prosthodontist selects the transgingival IOL abutment height, from 2 to 7 mm, with either internal or external connections. For esthetic reasons, the abutment-prosthesis junction is subgingival and not supragingival, as is permissible for a mandibular prosthesis.

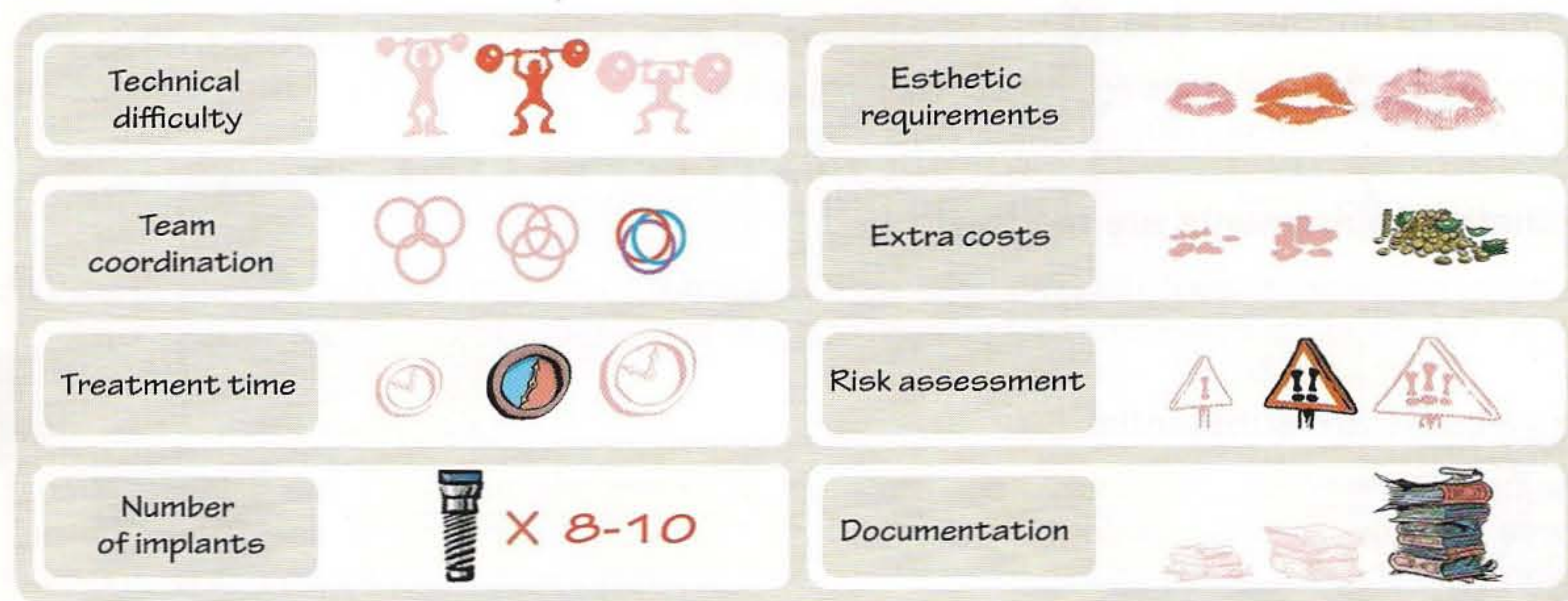
Healing caps must be placed on the transgingival abutments to protect the gingiva, even if the patient is just moving from the surgical treatment site to the prosthetic treatment site. They prevent the gingiva from collapsing during the time required for fabrication of the prosthesis.

2. If the prosthesis is cemented, healing abutments are screwed in the implants. Their height depends on the gingival thickness and the subcrestal implant position. It is best for the abutments to extend beyond the gingiva and the clot that has formed. They will be easier to manipulate during the prosthetic phase, which begins shortly after implant placement with the impression procedures and continues a few days later with delivery of the provisional prosthesis.

Suturing. The incisions are closed with single or mattress sutures around the extraction sites, both those that have been used for implant placement and those that have not.

Control radiograph. A radiograph is taken to assess the accuracy of implant placement, but it can be omitted if a radiograph is scheduled to be taken later by the same clinician after the implant copings are placed on external hex implants.

Transition from surgical treatment site to prosthetic treatment site. The transition from the surgical site to the prosthetic site should be planned in advance, to avoid any misunderstandings and to ensure that the patient experiences a seamless transition from one specialist to the other.



▲ **Fig 12-3** Key information for treatment option 1.

Prosthetic phase: Treatment option 1

Screw-retained provisional prosthesis placed within 48 to 72 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

Reminder

- This option is selected when a screw-retained prosthesis is preferred.
- The surgeon must ensure that the axes of the implants are compatible with palatal and occlusal emergence of the screw access paths.
- With this approach, a screw-retained prosthesis can be fabricated in 72 hours.
- If high strength and long wear are critical, the prosthesis should be prepared with a metal framework.

Key information for treatment option 1

Figure 12-3 summarizes the key aspects of prosthetic treatment in accordance with treatment option 1.

Technical difficulty is average

The screw access paths have to emerge palatally or occlusally, depending on tooth localization. The laboratory fabricates the prosthesis after the prosthodontist has sent the impression. After seating the prosthesis, the clinician must adjust the occlusion. This task increases the technical difficulty to average.

Team coordination is tight

The surgical and prosthetic phases are accomplished in two distinct sessions. The prosthodontist takes an impression immediately after implant placement, and the laboratory constructs the prosthesis as quickly as possible.

Treatment time is average

The prosthetic phase does not immediately follow surgery. Surgical time is unaffected, and the prosthetic phase is relatively short. About 2 to 3 hours are needed for surgery, and 1.5 to 2.5 hours are required for the two-stage prosthetic phase. The prosthodontist takes a postsurgical impression, and then the laboratory-constructed prosthesis is delivered in a separate session within 72 hours of surgery.

Number of implants: 8 to 10

Some authors have suggested that six implants will suffice,^{19,20} but with that limited number, any implant failure becomes difficult to manage.

Esthetic requirements are moderate

Esthetic requirements are usually moderate for this indication. However, to obtain an optimal esthetic result, the criteria for correct implant positioning have to be strictly followed (see chapter 5).

Extra costs are substantial

The provisional prosthesis requires specific prosthetic components that have a substantial cost. These component costs cannot be defrayed by their use in the final prosthesis. When the provisional prosthesis is provided with a metal framework, costs are increased even more. On the other hand, if use of this prosthesis is required for more than 6 months, this strengthened prosthesis makes the cost reasonable in relation to the longevity and comfort it provides, in contrast to a removable denture.

Additional risk is moderate

Obtaining good primary stability is sometimes a problem, especially when implants are placed in extraction sites. It is preferable to splint the implants in a metal-reinforced prosthesis. The esthetic risk of this protocol has not yet been fully evaluated.

Documentation in the literature is extensive

This indication is the one that is best documented in the literature after the edentulous mandible. Use of this option is often reported in the literature.²⁻⁶

Sequence and timing of steps for treatment option I

Figure 12-4 illustrates the treatment chronology for option 1:

- The laboratory work proceeds in two stages. Before implant placement, the laboratory fabricates the surgical guide and the individualized impression tray. Afterward, the laboratory constructs the prosthesis, with or without a metal framework.
- Implants are placed in the usual way, according to the established rules for the procedure.
- The prosthodontist takes an impression immediately after completion of the surgical procedure.
- The laboratory makes the provisional prosthesis. The prosthodontist places it in the patient's mouth 48 to 72 hours after implant placement.
- After 6 months of function, which corresponds to the time necessary for soft tissue maturation, implant stability is tested and the esthetic status of the provisional prosthesis is evaluated.
- The final prosthetic phase can proceed in the conventional manner.

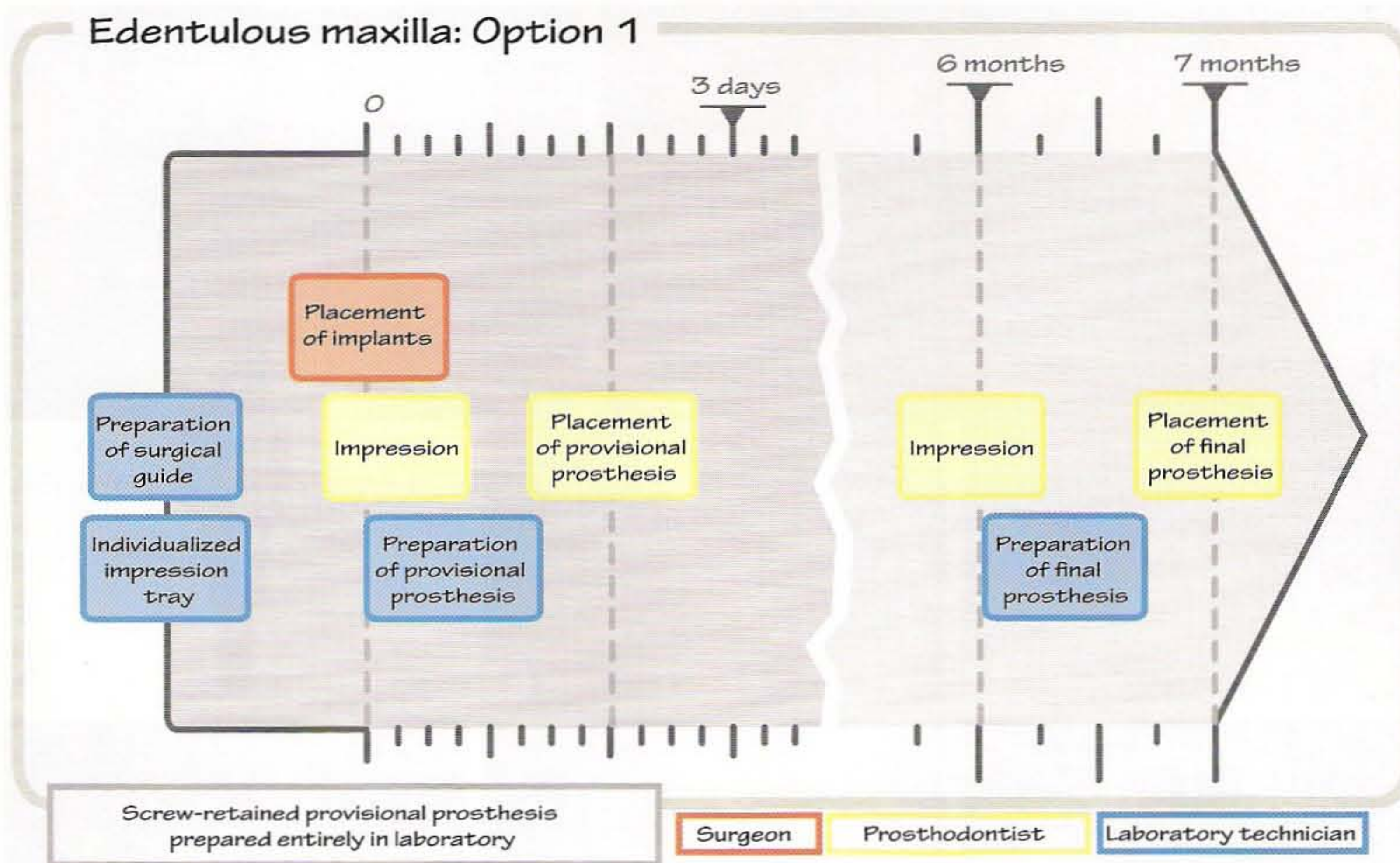
Checklist of materials required for treatment option I

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Individualized impression tray

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments or transgingival IOL abutments with healing caps (surgeon)
- Screwdriver for the healing abutments or the healing caps (surgeon and prosthodontist)
- Materials needed for a pick-up impression include either:
 - Impression copings for the transgingival IOL abutments (prosthodontist)
 - Impression copings for the implants (prosthodontist)



▲ **Fig 12-4** Sequence and timing of steps for treatment option 1. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

- **Analogs (laboratory):**
 - Implant analogs when the impression is taken of the implant neck
 - Abutment analogs when the impression is taken on the abutment
- Cylindrical abutments or castable UCLA abutments if the laboratory prepares a metal framework:
 - Adapted to the implants if the prosthesis rests directly on the implant neck
 - Adapted to the abutments if the prosthesis rests on the abutments

Immediate-loading protocol

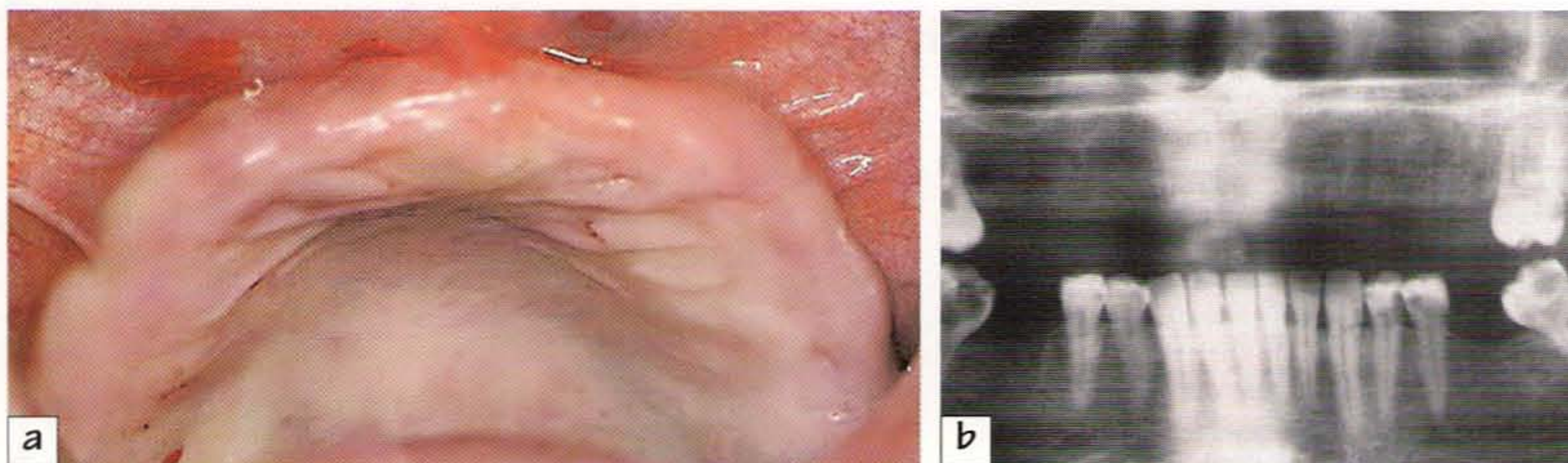
Presurgical and surgical phases

The presurgical and surgical procedures discussed earlier in the chapter are the same for all options. When those phases are concluded, the patient is provided with healing abutments or transgingival abutments with healing caps.

The following case illustrates how the prosthetic phase is conducted in accordance with option 1. For this patient, healing abutments were placed at the close of the surgical intervention. However, transgingival abutments will replace them later to increase the tolerance for divergence of the screw-retained prosthesis.

Case history

The edentulous situation was assessed clinically (Fig 12-5a) and radiographically (Fig 12-5b); only two molars were present. As a general rule, posterior teeth, no matter how poor their prognosis may be, are retained as long as possible until the close of the provisional prosthetic phase. They are



▲ **Fig 12-5** Clinical situation before the start of the prosthetic phase. (a) Preoperative clinical view. (b) Preoperative panoramic radiograph.

extracted only later, unless they occupy a position that could be used effectively for implant placement. These remaining posterior teeth provide a good indication of the vertical dimension, facilitate the positioning of the surgical guide, and constitute a landmark when a wax bite is taken of the interocclusal relationship.

Ten implants were placed in healed sites; nine were to be immediately loaded and the most distal implant on the left side was to be left submerged. All had good primary stability (greater than 40 Ncm). All implants received healing abutments except the submerged one, which had received a healing screw.

Provisional prosthetic phase

Reminder

It is recommended that the prosthesis be reinforced with a cast metal bar to compensate for the limited acrylic resin mass of the prosthesis and the bone quality of the maxilla, which is not as supportive as that of the mandible. The few failures the authors have experienced have resulted from fracture of the prosthesis.

Screw-retained prostheses are placed:

- Directly on the implant neck when bone resorption is limited or when implants are located in extraction sites
- On transgingival IOL abutments when bone resorption in the maxilla is extensive (see the treatment variant described in the next section) or the tolerance for divergence needs to be increased

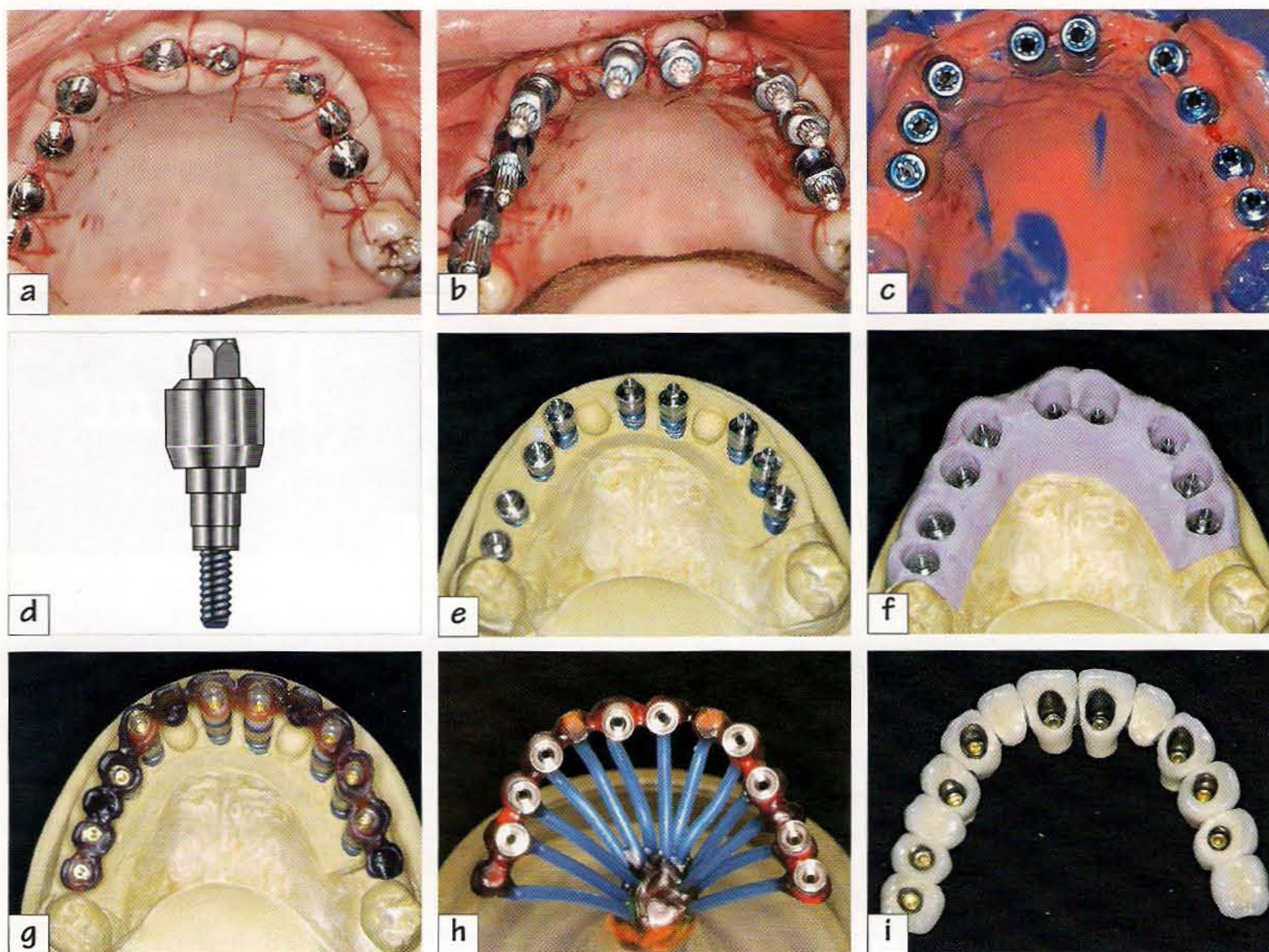
In the present case, 2-mm transgingival abutments were placed on the implants to increase the tolerance for divergence of the implants' internal connection. The patient arrives at the prosthetic office with healing abutments on the implants (Fig 12-6a).

Impression

The impression is taken directly on the implant necks. The healing abutments are removed and replaced with implant copings (Fig 12-6b). When external hex implants are used, the prosthodontist takes a control radiograph to ensure that the copings are well seated. If a poor fit is found, the clinician should correct the seating and take another control radiograph.

The individualized impression tray is tried in the mouth to ensure that it is well adapted to the postoperative conditions. The tray must not make contact with the impression copings; if it does, the window of the tray is enlarged to avoid this contact.

A wax sheet or a piece of adhesive tape is placed over the window before the impression material is placed to prevent diffusion of the material into the mouth. The prosthodontist first covers



▲ **Fig 12-6** Impression and laboratory procedures during the initial prosthetic phase. (a) Postoperative clinical view. The provisional prosthesis will be supported by nine implants. (b) Implant copings screwed in the implant necks. (c) Impression taken with impression copings of the internal hex implant. (d) Transgingival abutment (2 mm). In this case, it is used to increase the tolerance of the internal hex implants for divergent implants. (e) Placement of the transgingival abutments on the implant analogs on the cast. (f) Gingival prosthesis in place. The relationship with the abutments is satisfactory. (g) Wax mounting with the aid of castable UCLA abutments. (h) Setup ready for casting. The metal bases of the UCLA abutments are adapted to the transgingival abutments, not to the implant necks. (i) Provisional acrylic resin prosthesis with a metal framework. (Prosthesis by Dr S. Molloy and J-P. Benhamou.)

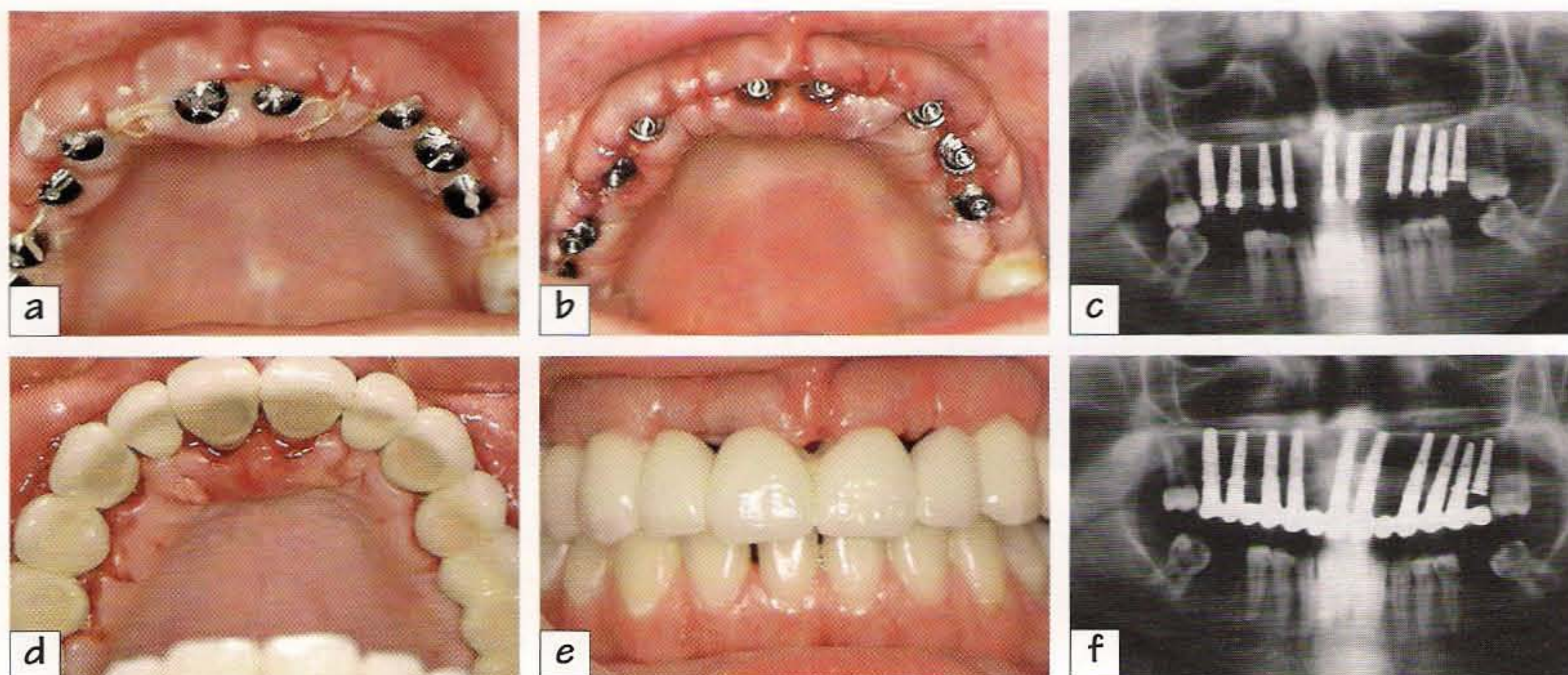
the copings with the impression material to take the pick-up impression. The impression coping screws are located and then unscrewed.

The finished impression (Fig 12-6c), together with a wax bite of the interocclusal relationship, is then sent to the laboratory to be poured with implant analogs.

When the impression is taken on transgingival IOL abutments that the surgeon placed before suturing, abutment impression copings are used.

Laboratory procedures

In accordance with the pick-up impression, the laboratory uses analogs of the abutments or the implants in pouring the cast. In this case, implant analogs were used; 2-mm transgingival abutments (Fig 12-6d) were screwed into the cast later (Fig 12-6e). The prosthetic gingiva is added to the impression and seated on the cast to clarify the relationship between the gingiva and the abutments (Fig 12-6f). A wax setup of the castable UCLA abutments is made for fabrication of the metal framework (Figs 12-6g and 12-6h). Figure 12-6i shows the finished provisional prosthesis.



▲ **Fig 12-7** Placement of the screw-retained provisional prosthesis in the mouth. (a) Clinical situation 72 hours after surgery. Note the healing caps and the initiation of soft tissue healing. (b) Situation after placement of the 2-mm IOL abutments. The abutment-prosthesis junction is subgingival on the buccal aspect; slight bleeding is normal. (c) Control radiograph taken after placement of the abutments. The abutments are well seated in the implants. (d) Occlusal view taken after the screw access paths have been filled with resin composite. (e) Provisional prosthesis in occlusion. The large anterior embrasures will allow the papillae to migrate in a coronal direction. (f) Panoramic radiograph taken after placement of the prosthesis. Note the presence of the abutments and the more radiopaque metal framework as well as the difference in diameter between the 5- and 4-mm abutments. An unintentional platform-switching procedure has been performed. The most distal implant on the left is not loaded; it will be held in reserve as a security implant, should the adjacent implant fail. (Prosthesis by Dr S. Molloy and J-P. Benhamou.)

Delivery of provisional prosthesis

The provisional prosthesis is ready for placement within 48 to 72 hours after surgery. The patient arrives at the prosthodontist's office with healing abutments in place (Fig 12-7a), which the prosthodontist replaces with the 2-mm transgingival abutments (Fig 12-7b). After 72 hours, this procedure causes no significant bleeding because by that time healing is well under way. The prosthodontist takes a control radiograph to ensure that the abutments have been seated completely in the implants (Fig 12-7c). The prosthesis is then ready to be placed in the patient's mouth. The passive fit of the prosthesis is confirmed, and then the prosthodontist attaches it to the transgingival abutments. The screw access holes are obturated with gutta-percha and then resin composite (Fig 12-7d).

Figure 12-7e shows the prosthetic result. The occlusion is adjusted to distribute stresses evenly and the smile line is assessed. In this patient, the smile line was low. Depending on the outcome of soft tissue healing, a decision about the need for gingival grafting will be made after 6 months.

Large anterior embrasures encourage the development of the papilla. The presence of a metal framework allows large embrasures; without the framework, the embrasures have to be kept small so that the acrylic resin prosthesis can be bulkier and thus more fracture resistant.

Control radiograph

At the close of this prosthetic visit, a control radiograph is taken (Fig 12-7f). It will serve as a baseline reference to evaluate bone status over time.

Treatment variant: Final acrylic resin prosthesis with metal framework delivered within 72 hours

In this variant for treatment of the edentulous maxilla, a final screw-retained acrylic resin prosthesis with a metal framework is fabricated shortly after implant placement. In this case, a patient's maxilla had suffered advanced bone loss (Figs 12-8a and 12-8b). An extremely limited amount of vertical bone was available in the posterior regions (see Fig 12-8b). For financial reasons, the patient desired to have his final denture immediately, thus eliminating the provisional step.

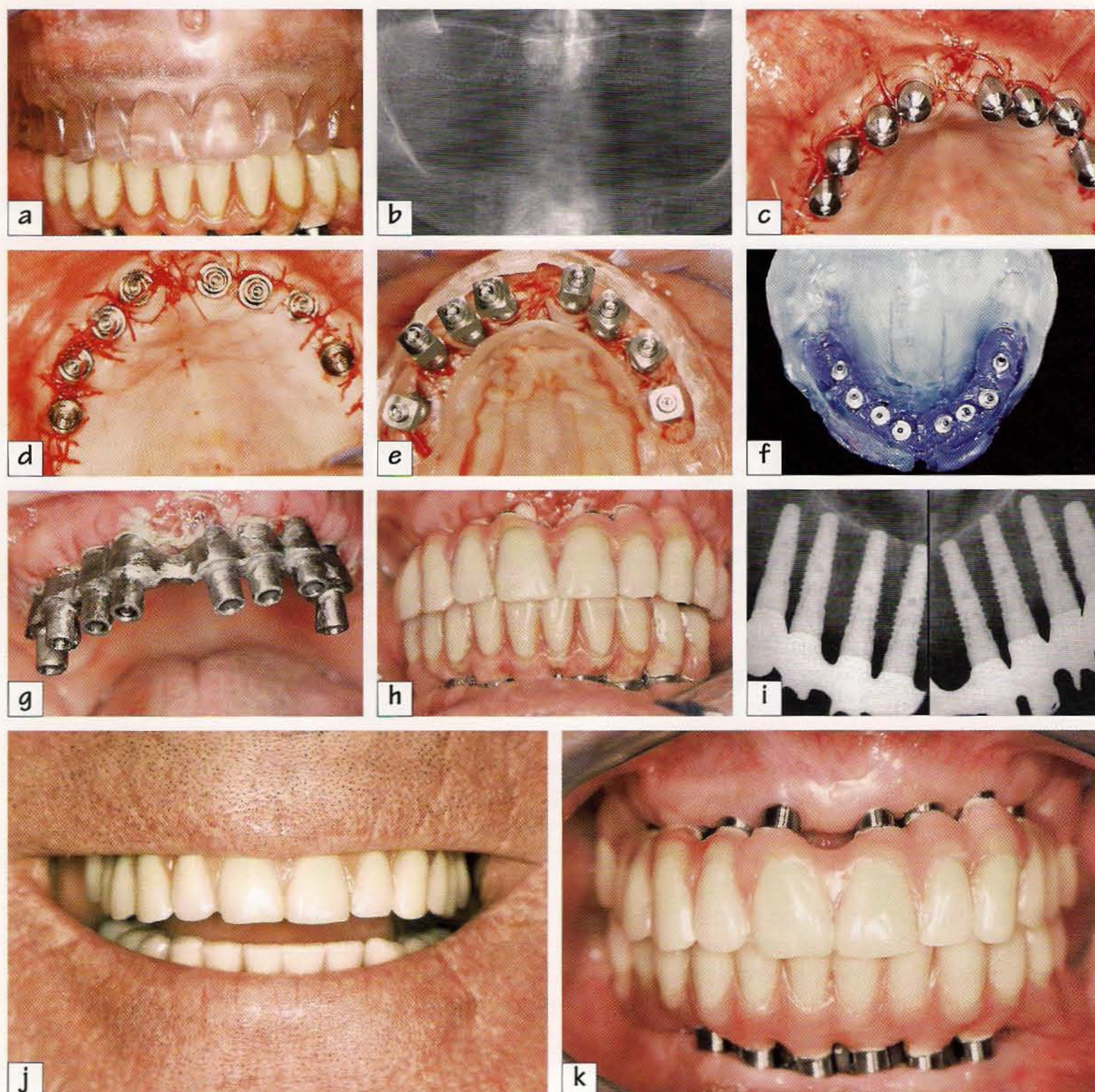
Eight implants, seven that were 4 mm in diameter and one that was 5 mm in diameter, were placed anterior to the maxillary sinuses. Implants sites were underprepared and primary stability was satisfactory (greater than 40 Ncm) for all implants. Transgingival abutments, 4 mm long, were screwed in the implants and fitted with their healing caps. With suturing of the gingiva (Fig 12-8c), the surgical phase was completed.

The patient was moved to the prosthetic site; there the caps of the IOL abutments were removed (Fig 12-8d), and the implant copings were placed on the transgingival abutments (Fig 12-8e). An impression was taken with the surgical guide, which served as an individualized tray (Fig 12-8f). This guide was a duplicate of the patient's prosthesis; it was generously hollowed in the region of the implants and included the occlusal surfaces of the molars. It also provided a registration of the interocclusal relationship during the impression procedures. The surgical guide, therefore, fulfilled three functions. It served as (1) a surgical guide, (2) an individualized impression tray, and (3) a registration of the interocclusal relationship.

A cast incorporating analogs of the IOL abutments was poured. A metal framework was cast over the UCLA abutments fitting the IOL abutments and was tried in the mouth 48 hours after surgery (Fig 12-8g). After passive fit was confirmed, the laboratory mounted the acrylic resin teeth on the framework.

The finished prosthesis was tried in the mouth within 72 hours after surgery (Fig 12-8h). Because of the considerable amount of bone resorption, prosthetic gingiva had to be added in the form of pink acrylic resin. A control radiograph revealed the close fit of the implants and the metal framework (Fig 12-8i). Figure 12-8j, a smiling view of the patient wearing the final prosthesis, shows the final result.

The osseointegration period proceeded without complication. At the 1-year follow-up visit, gingival recession of 1 to 3 mm was observed (Fig 12-8k). The IOL abutments became uncovered, and the hybrid character of the prosthesis became evident. However, the actual esthetic result of the prosthesis was unaffected because of the patient's low smile line (see Fig 12-8j).



▲ **Fig 12-8** Treatment with a variant of option I. The final prosthesis will be delivered within 72 hours. (a) Preoperative clinical view. (b) Preoperative panoramic radiograph. (c) Postoperative view. Eight implants with 4-mm-high transgingival abutments have been placed. The healing caps emerge into the oral cavity. (d) Removal of healing caps in preparation for the impression. (e) Impression copings placed on the transgingival IOL abutments. (f) Impression taken with the surgical guide serving as an individualized tray. (g) Try-in of the metal framework mounted on the base of the castable UCLA abutments. (h) Intraoral view after placement of the final prosthesis. (i) Radiographs taken after placement of the final prosthesis. (j) Patient's smile after placement of the final prosthesis. (k) Clinical view at the 1-year recall examination. The gingiva has receded 1 to 3 mm apically but remains healthy. (Prosthesis by Dr B. Jakubowicz-Kohen.)

Prosthetic phase: Treatment option 2

Screw-retained provisional prosthesis placed within 24 hours after surgery; the removable denture is attached to provisional cylinders in the laboratory, according to the denture conversion technique.

Reminder

This option, which employs the conversion prosthesis technique, is chosen when:

- Considerable bone resorption has taken place and the buccal soft tissues need support.
- The implants' axes are compatible with palatal anterior and occlusal posterior screw access paths.

Key information for treatment option 2

Figure 12-9 summarizes the key aspects of the prosthetic treatment in accordance with treatment option 2.

Technical difficulty is average

The screw access paths have to emerge palatally or occlusally, depending on the location of the tooth. After the clinician has taken an impression with the implants and abutments in place, the laboratory attaches the denture to the cylinders. After seating the denture, the clinician has to adjust the occlusion. This task increases the technical difficulty to average.

Team coordination is tight

The surgical and prosthetic phases are accomplished in two distinct sessions. The prosthodontist takes an impression immediately after implant placement and the laboratory constructs the prosthesis as swiftly as possible.

Treatment time is average

The prosthetic phase is not consecutive to surgery. Surgical time is unaffected, and the prosthetic phase is relatively short. The total treatment time includes 2 to 3 hours for the surgical intervention and 1.5 to 2.5 hours for the two-stage prosthetic phase. The prosthodontist takes a postsurgical impression, and the laboratory-constructed prosthesis is delivered in a separate session within 72 hours.

Number of implants: 8 to 10

With this number of implants, the functional stress can be evenly distributed between implants.

Esthetic requirements are low or nonexistent

Esthetic considerations are usually negligible for this indication in patients with advanced bone resorption.

Extra costs are substantial

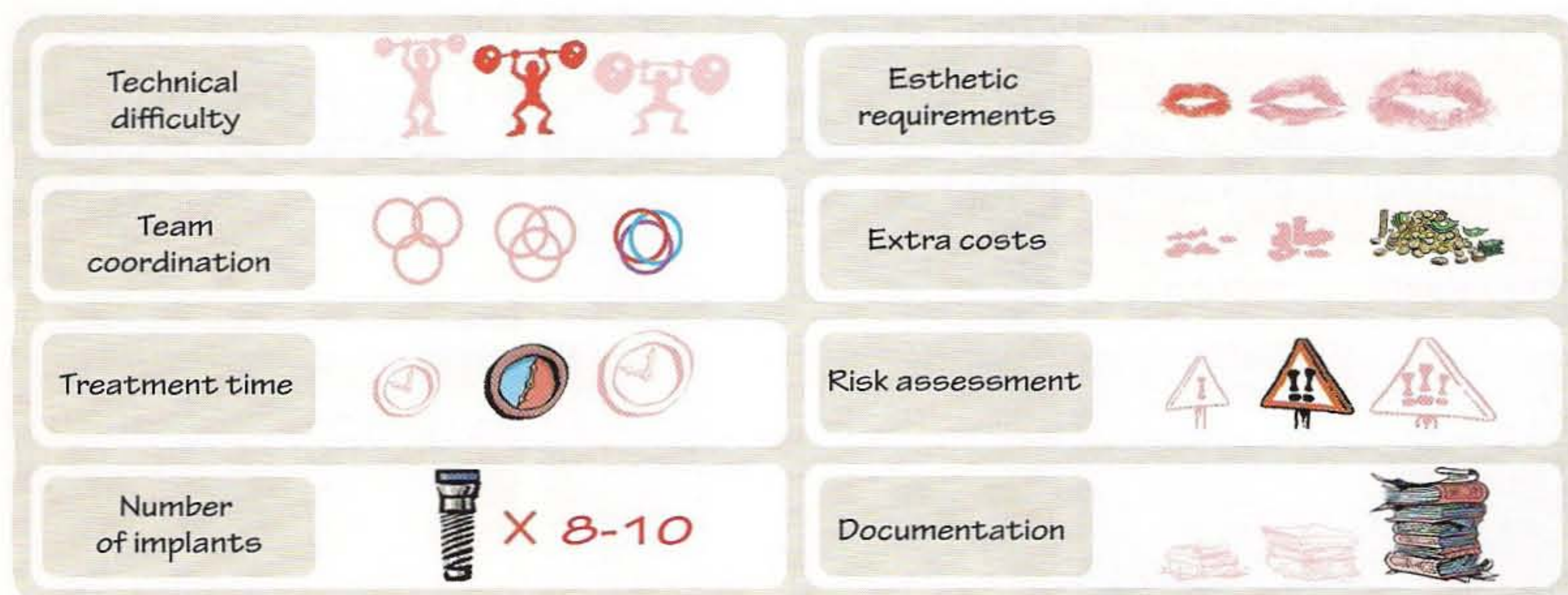
The provisional prosthesis requires specific prosthetic components that have a substantial cost. The cost of these components cannot be defrayed by their use in the final prosthesis.

Additional risk is moderate

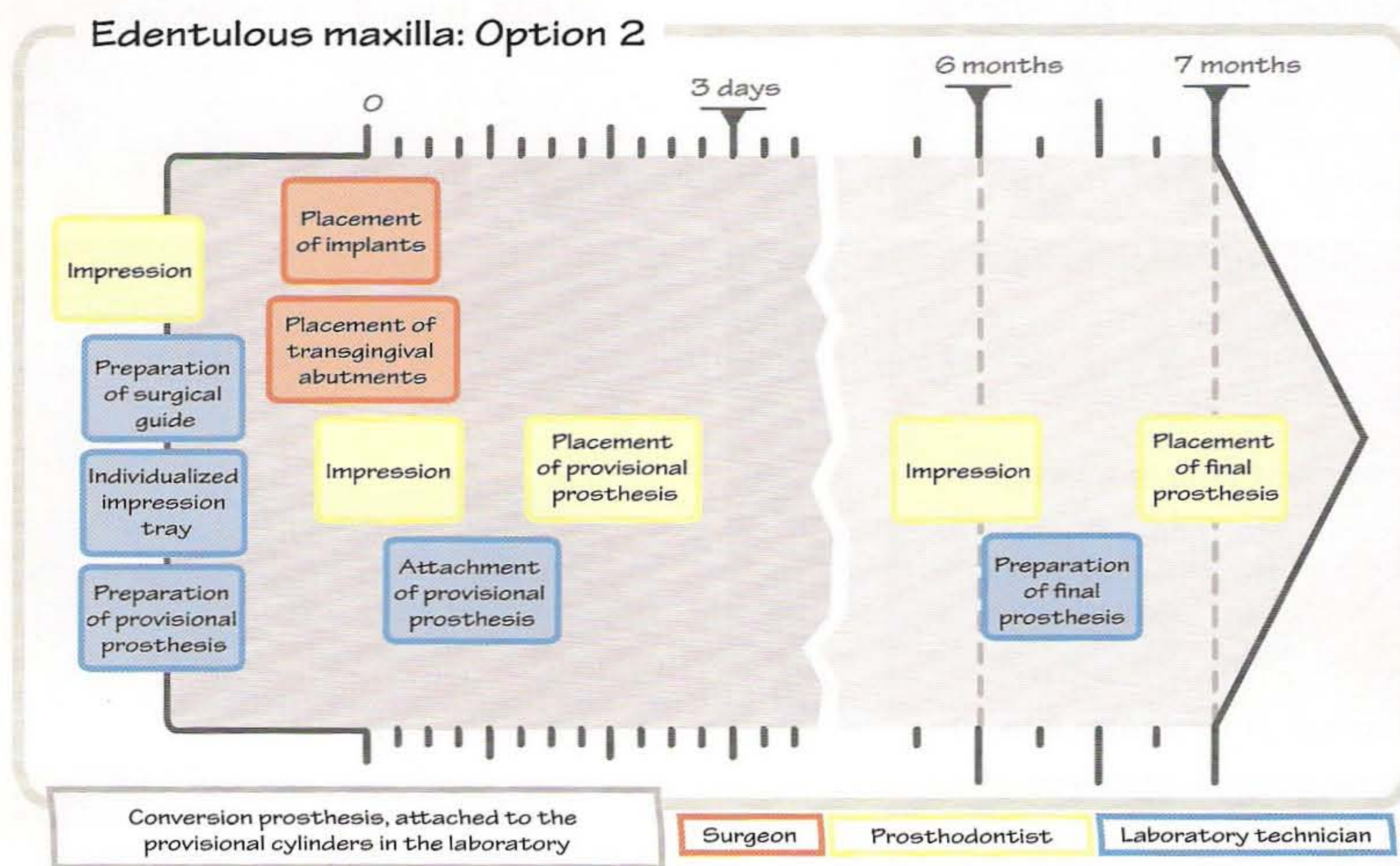
Obtaining good primary stability is sometimes a problem, especially when implants are placed in extraction sites.

Documentation in the literature is extensive

Although immediate loading in the edentulous maxilla is one of the best documented indications in the literature, this particular option has been described only rarely.



▲ **Fig 12-9** Key information for treatment option 2.



▲ **Fig 12-10** Sequence and timing of steps for treatment option 2. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Sequence and timing for treatment option 2

Figure 12-10 illustrates the treatment chronology for option 2:

- The laboratory participates before and after implant placement. Before, the laboratory prepares the surgical guide, the removable denture, and the individualized impression tray. Afterward, the laboratory attaches the denture to the provisional cylinders and finishes preparation of the provisional prosthesis.
- Implants are placed according to the established rules for the procedure.
- The prosthodontist takes an impression immediately after completion of the surgical procedure.

- The prosthetic phase is completed in a second distinct session within 72 hours after implant placement, depending on the availability and the location of the laboratory.
- After a 6-month healing period in which osseointegration is completed, the prosthodontist verifies implant stability.
- The final prosthetic phase can proceed in the conventional manner

Checklist of materials required for treatment option 2

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Removable prosthesis made from diagnostic waxup
- Individualized impression tray
- Stock of acrylic resin from the same lot used to make the prosthesis so that retouched areas will blend in acceptably.

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Transgingival IOL of the estimate length and their healing caps as well as additional abutments of varying lengths in case the pretreatment estimate of height has not been accurate (surgeon)
- Healing caps (surgeon)
- Screwdriver for the healing caps (surgeon and prosthodontist)
- Materials needed for a pick-up impression, including as many impression copings as there are implants (prosthodontist)
- Analogs of the transgingival abutments (laboratory)
- Polishing protectors for the IOL abutments during the final polishing procedure (laboratory)
- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

The presurgical and surgical procedures are the same for all options. The following case illustrates how the prosthetic phase is conducted in accordance with option 2.

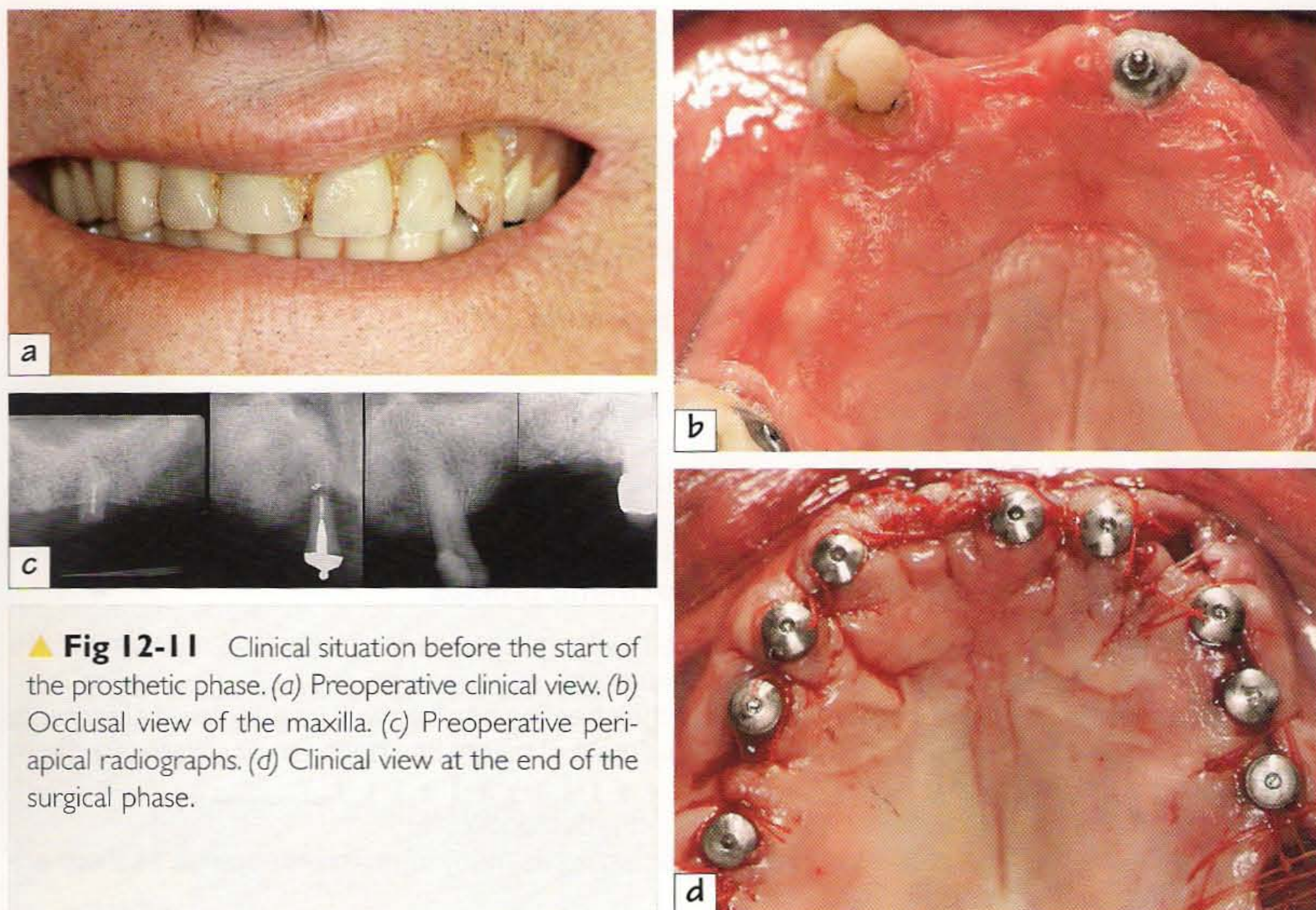
Case history

An 80-year-old patient with an almost edentulous maxilla presented for an implant-supported rehabilitation (Fig 12-11a). He had four remaining teeth; bone resorption in the remainder of the arch was advanced (Figs 12-11b and 12-11c). His removable partial denture provided important support to his upper lip. For this reason, the conversion prosthesis technique was considered, in order to transform his denture from a removable denture to a fixed prosthesis. The laboratory would construct the provisional prosthesis and it would be delivered 24 hours after surgery.

The surgeon placed 10 implants, on which transgingival IOL abutments were fitted. The patient left the surgeon's office with healing caps in place (Fig 12-11d).

Provisional prosthetic phase

For this patient, a new complete denture, to be converted later, was made before surgery (Figs 12-12a to 12-12b). The first prosthetic step consists of taking an impression so that the laboratory can attach the denture to the provisional titanium cylinders.



▲ **Fig 12-11** Clinical situation before the start of the prosthetic phase. (a) Preoperative clinical view. (b) Occlusal view of the maxilla. (c) Preoperative peri-apical radiographs. (d) Clinical view at the end of the surgical phase.

Impression

The healing caps are removed (Fig 12-12c), and the impression copings are screwed on the IOL abutments. The individualized impression tray is placed on the copings. The copings are first covered with the impression material to take the pick-up impression. The impression, together with a wax bite of the interocclusal relationship, is sent to the laboratory to be poured with abutment analogs (Figs 12-12d to 12-12f).

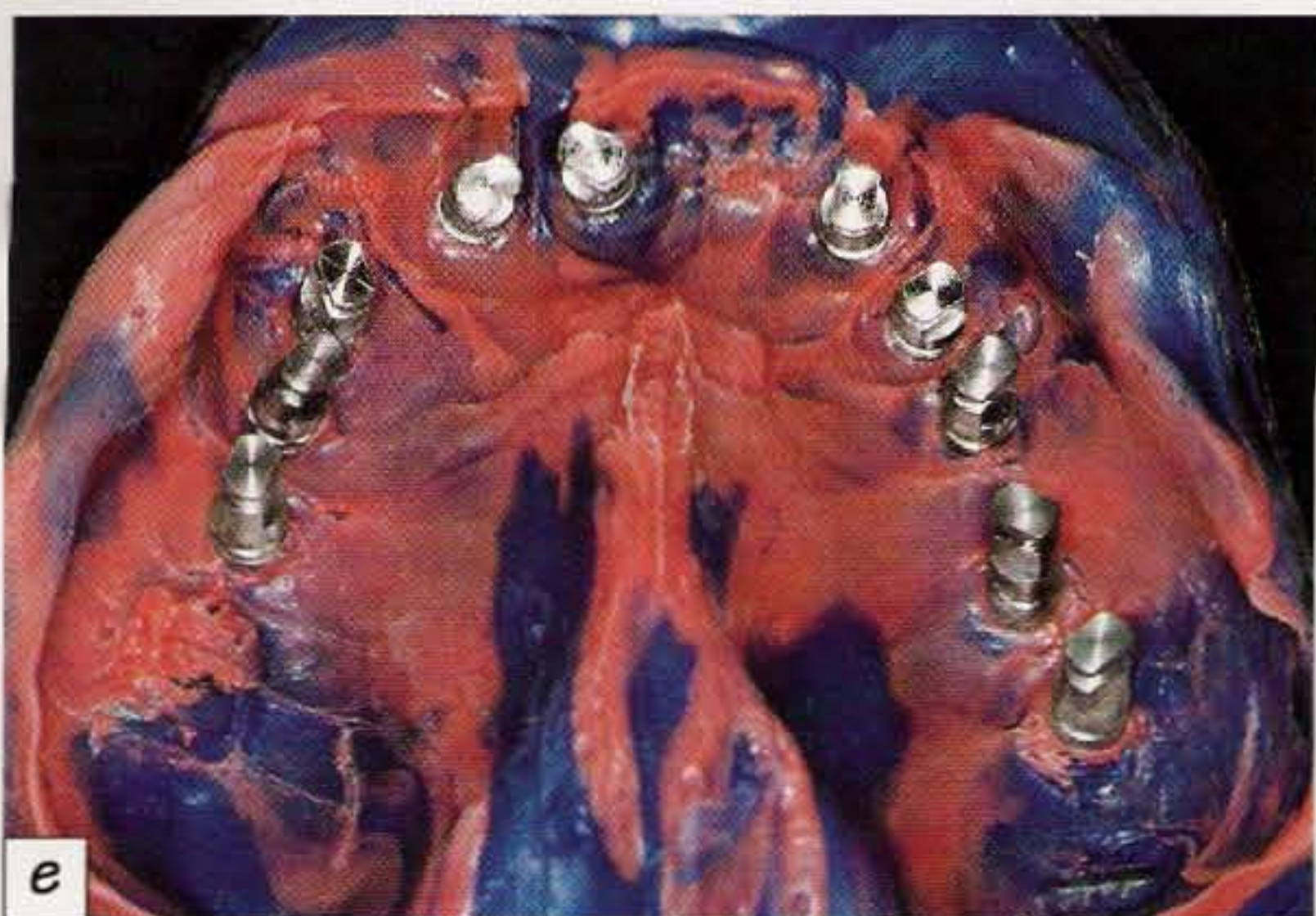
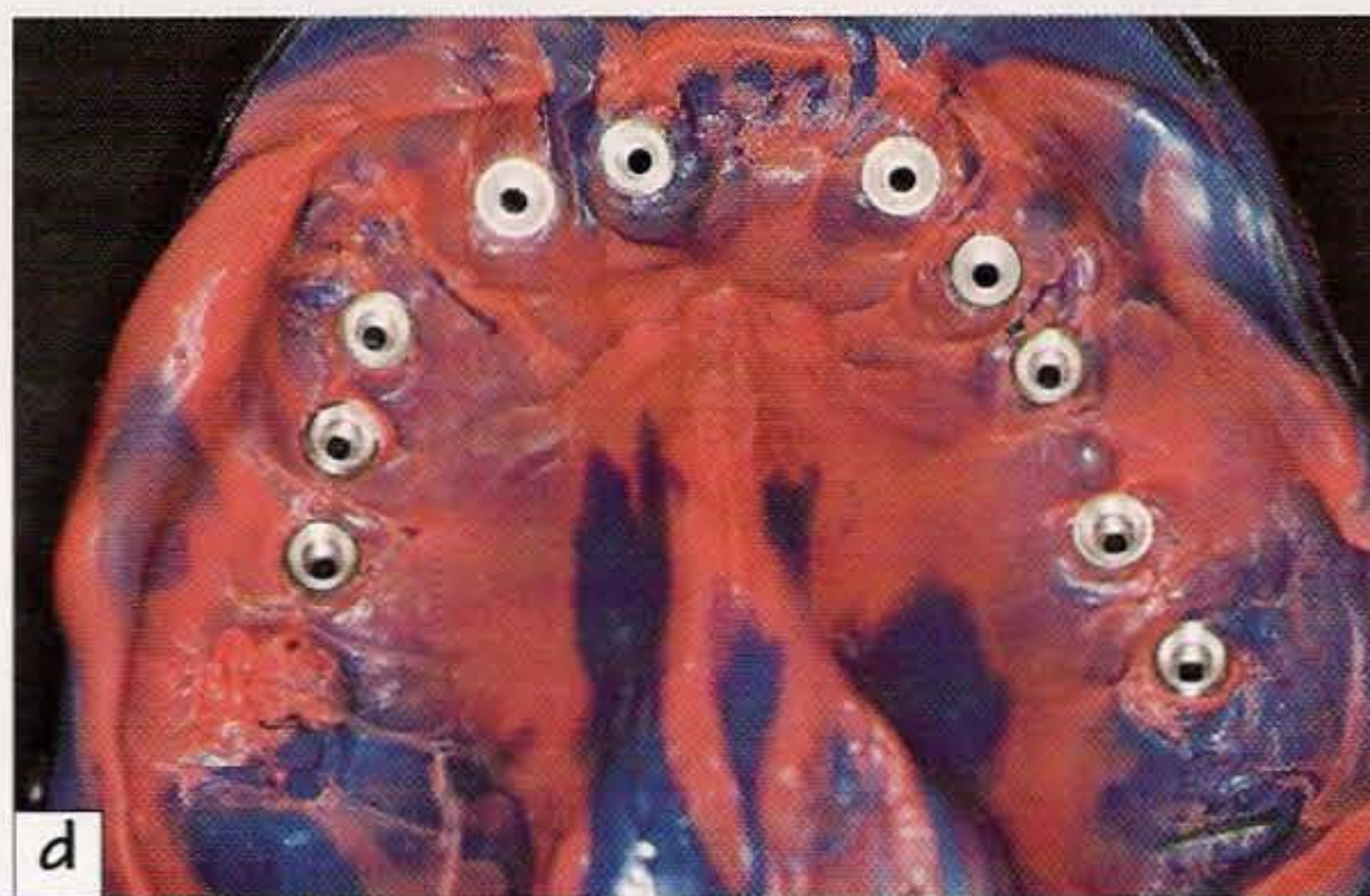
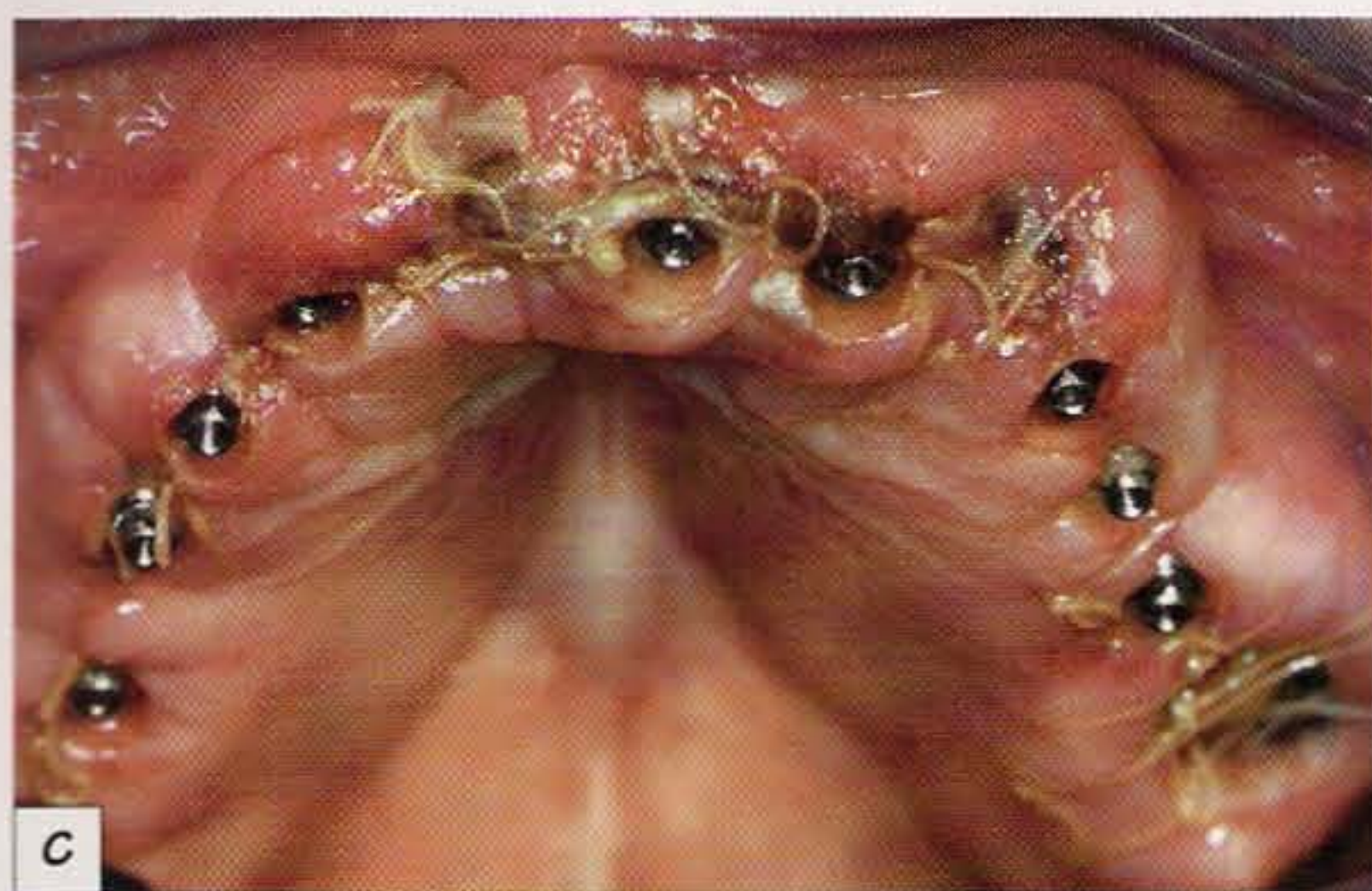
Laboratory procedures

The laboratory pours the impression with the abutment analogs and screws the provisional titanium cylinders into the abutments. The prosthesis is hollowed where it will engage the implants and is placed over the cylinders. In this case, divergence of the implants was limited, so the openings in the denture were not extensive. The emergence paths of the screws were palatal in the incisal and canine regions and occlusal in the posterior segments (Fig 12-12g). The cylinders are trimmed to the appropriate size, the gaps around the cylinders are filled with acrylic resin material, and the prosthesis is polished. Before the interior surface is polished, the protective screws are attached to the cylinders. Figures 12-12g and 12-12h show the prosthesis ready to be fixed in the mouth, 24 hours after surgery.

Delivery of prosthesis

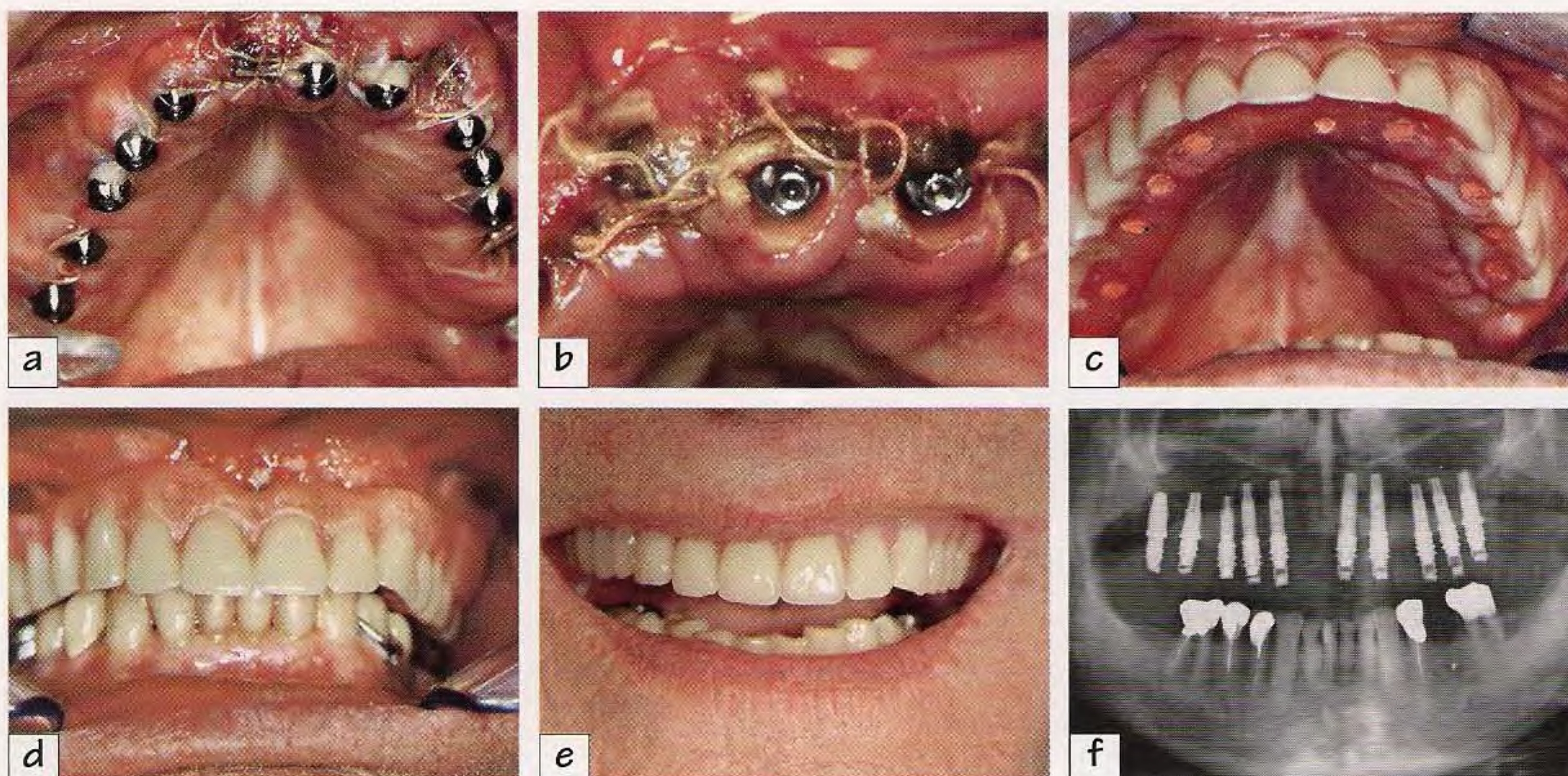
The patient arrives with the protective healing caps in place (Fig 12-13a). They are removed (Fig 12-13b), and access to the transgingival IOL abutments is gained. The denture is placed and attached with the gold screws (Fig 12-13c). The occlusion is adjusted (Fig 12-13d), and the screw access paths are filled with gutta-percha.

For this patient, a screw-retained prosthesis, converted from a removable partial denture, was the only means of providing good support to the patient's upper lip during the provisional restoration period (Fig 12-13e). It aided correct phonation and clear pronunciation of words without

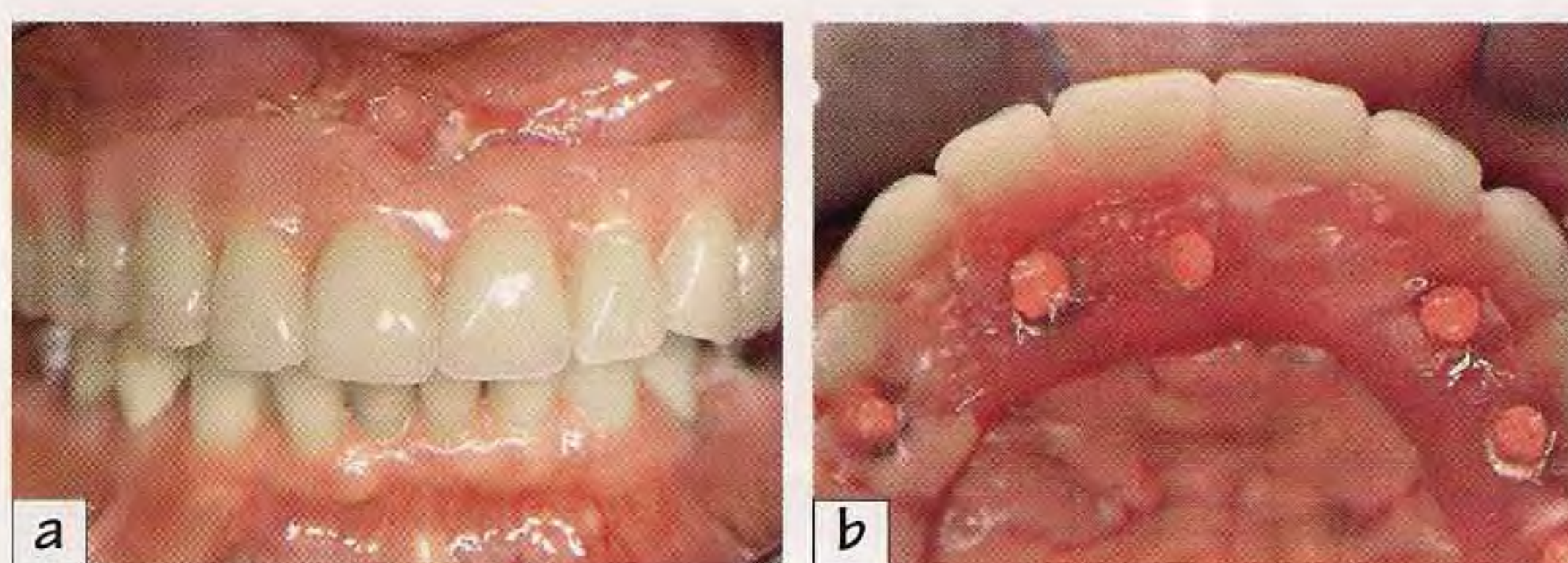


▲ **Fig 12-12** Impression and laboratory procedures during the initial prosthetic phase. (a) Maxillary denture, prepared before surgery. (b) Occlusal view of the maxillary denture. (c) Removal of the healing caps in preparation for the impression. (d) Impression with the transgingival abutment impression copings in place. (e) Abutment analogs connected to the transfer copings of the impression. (f) Interocclusal impression. (g) Fixed conversion prosthesis, adapted from a removable denture. (h) Inner surface of the fixed prosthesis. (Prosthesis by Dr S. Molloy and J-P. Benhamou.)





▲ **Fig 12-13** Placement of a screw-retained provisional prosthesis. (a) Clinical view at the beginning of the prosthetic appointment. (b) Condition of the soft tissues after removal of the healing caps. (c) Occlusal view of the fixed prosthesis. (d) Prosthesis in occlusion. (e) Patient's smile at the close of the prosthetic appointment. (f) Radiograph taken after placement of the fixed provisional prosthesis. The provisional cylinders rest on the transgingival abutments. Most of the implants are 5 mm in diameter; because the transgingival abutments are 4 mm in diameter, an unintentional platform-switching procedure has been performed. (Prosthesis by Dr S. Molloy and J-P. Benhamou.)



▲ **Fig 12-14** Follow-up examination. (a) Clinical situation during the first week. The gingiva is healing properly and the patient's oral hygiene has been acceptable. (b) Occlusal view of the prosthesis. (Prosthesis by Dr S. Molloy and J-P. Benhamou.)

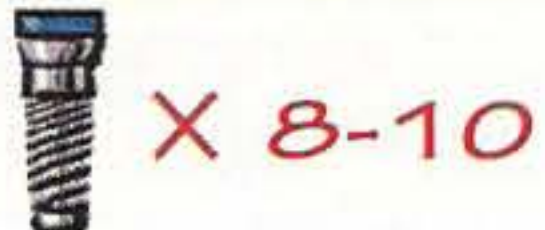
any of the whistling sounds that would have occurred with a traditional fixed prosthesis because of the advanced bone loss. Much of the buccal margin of the denture was removed to promote good oral hygiene (see Fig 12-12h).

Control radiograph

The radiograph indicated that all the prosthetic components were well seated (Fig 12-13f). It will serve as a baseline reference to evaluate bone status over time.

Follow-up

At 1 week, the healing of the soft tissues was progressing well (Fig 12-14a). The large buccal openings in the denture allowed the patient to maintain good oral hygiene. The occlusal view shows the extent of the palatal coverage in the prosthesis (Fig 12-14b).

Technical difficulty		Esthetic requirements	
Team coordination		Extra costs	
Treatment time		Risk assessment	
Number of implants		Documentation	

▲ **Fig 12-15** Key information for treatment option 3.

Prosthetic phase: Treatment option 3

Cemented provisional prosthesis placed within 72 hours after surgery; provisional abutments and the prosthesis are prepared in the laboratory.

Reminder

- This option is chosen when a cemented prosthesis is most appropriate for the situation and when the patient has a thick periodontal biotype.
- With this approach, a fixed prosthesis can be cemented within 72 hours after implant placement.

Key information for treatment option 3

Figure 12-15 summarizes the key aspects of prosthodontic treatment in accordance with treatment option 3.

Technical difficulty is average

The laboratory constructs the prosthesis and can compensate for any divergence of the implants with relative ease by adjusting the abutments. However, the prosthodontist will still have to adjust the occlusion of the prosthesis with precision.

Team coordination is tight

The surgical and prosthetic phases are accomplished in two distinct sessions. The prosthodontist takes an impression immediately after implant placement and the laboratory constructs the prosthesis as quickly as possible.

Treatment time is average

The surgical and the prosthetic phases are not immediately consecutive. The surgical phase is unchanged and the prosthetic phase is relatively short. About 2 to 3 hours are needed for surgery, and 1.5 to 3 hours are required for the two-stage prosthetic phase, which is divided into a session for taking the impression after the surgery and another session for delivering the prosthesis. Time must be spent to meticulously remove any excess cement.

Number of implants: 8 to 10

Some authors suggest that six implants will suffice,^{19,20} but with that limited number any implant failure becomes difficult to manage.

Esthetic requirements are moderate

Esthetic considerations are usually moderate for this indication. However, for the best esthetic results, implants must follow the strict rules of implant positioning (see chapter 5).

Extra costs are substantial

The provisional prosthesis requires specific prosthetic components that have a substantial cost. Usually, the cost of these components is not defrayed by their use in the final prosthesis. To reduce the cost, however, it is possible to incorporate them in the final prosthesis, but the patient must remain edentulous during fabrication of the final prosthesis.

Additional risk is moderate

Obtaining good primary stability is sometimes a problem, especially when implants are placed in extraction sites. It is preferable to splint implants in a metal-reinforced prosthesis. The esthetic risk of this protocol has not yet been fully evaluated.

Documentation in the literature is extensive

This indication is one of the best documented in the literature, after its use in the edentulous mandible. This option is often reported in the literature.²⁻⁶

Sequence and timing of steps for treatment option 3

Figure 12-16 illustrates the treatment chronology for option 3:

- The laboratory participates before and after implant placement. Before, the laboratory prepares the surgical guide and the individualized impression tray. Afterward, the laboratory prepares the abutments and constructs the prosthesis.
- The implants are placed in accordance with established rules for the procedure.
- The prosthodontist takes an impression after implant placement.
- The laboratory prepares the provisional abutments and the provisional prosthesis. The prosthodontist will cement the prosthesis in the mouth within 72 hours after implant placement.
- After 6 months of functioning, during which maturation of the soft tissues takes place, the clinical stability of the implants is tested before the final prosthesis is fabricated. At this time, the esthetic status is also evaluated.
- The fabrication of the final prosthesis, which incorporates new abutments, can begin.

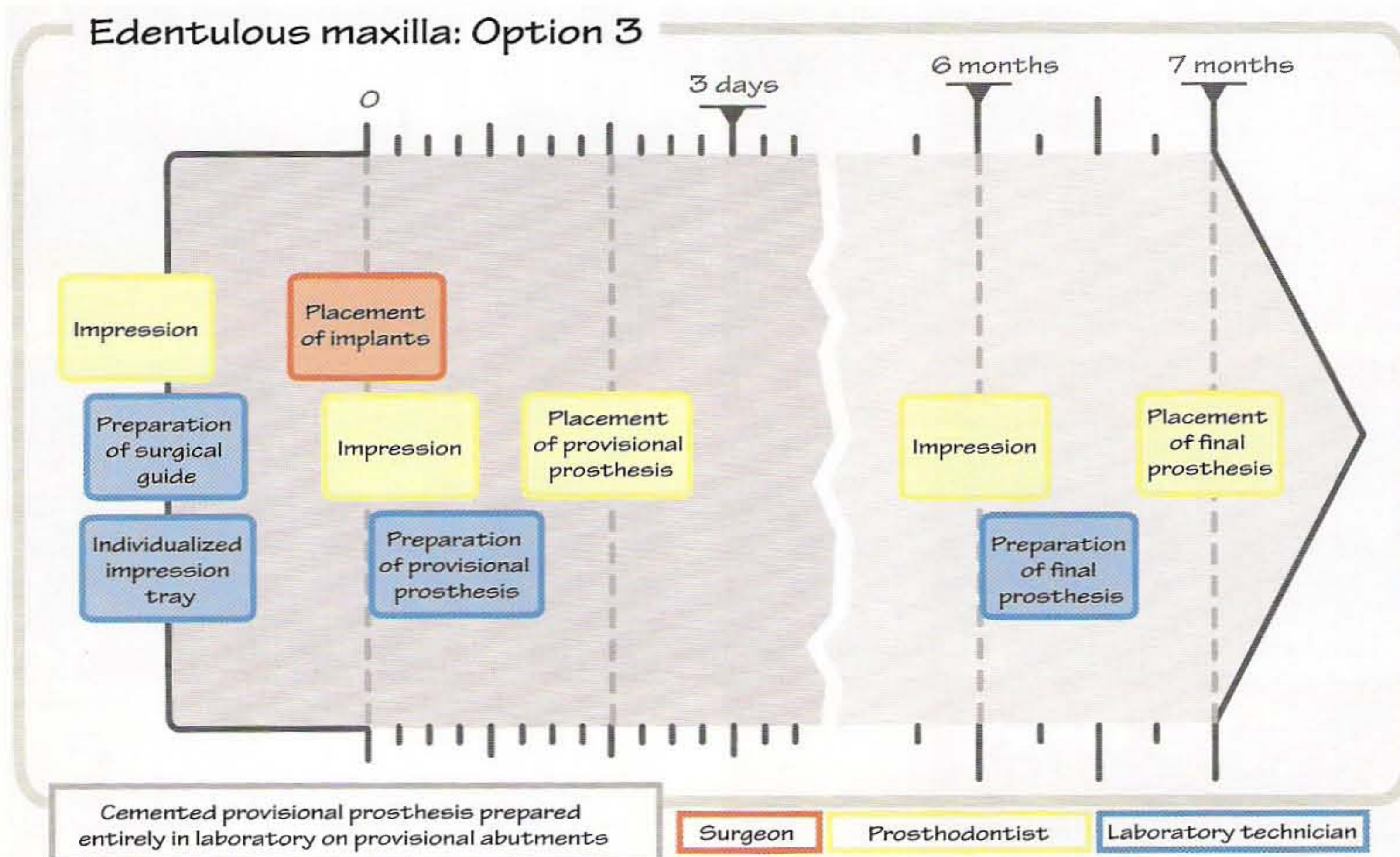
Checklist of materials required for treatment option 3

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Individualized impression tray

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Materials needed for a pick-up impression, including enough impression copings for all the implants (prosthodontist)



▲ **Fig 12-16** Sequence and timing of steps for treatment option 3. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

- Titanium abutments (laboratory)
- Implant analogs (laboratory)
- Try-in screws (prosthodontist, laboratory)
- Gold screws (prosthodontist)
- Temporary cement (prosthodontist)

Immediate-loading protocol

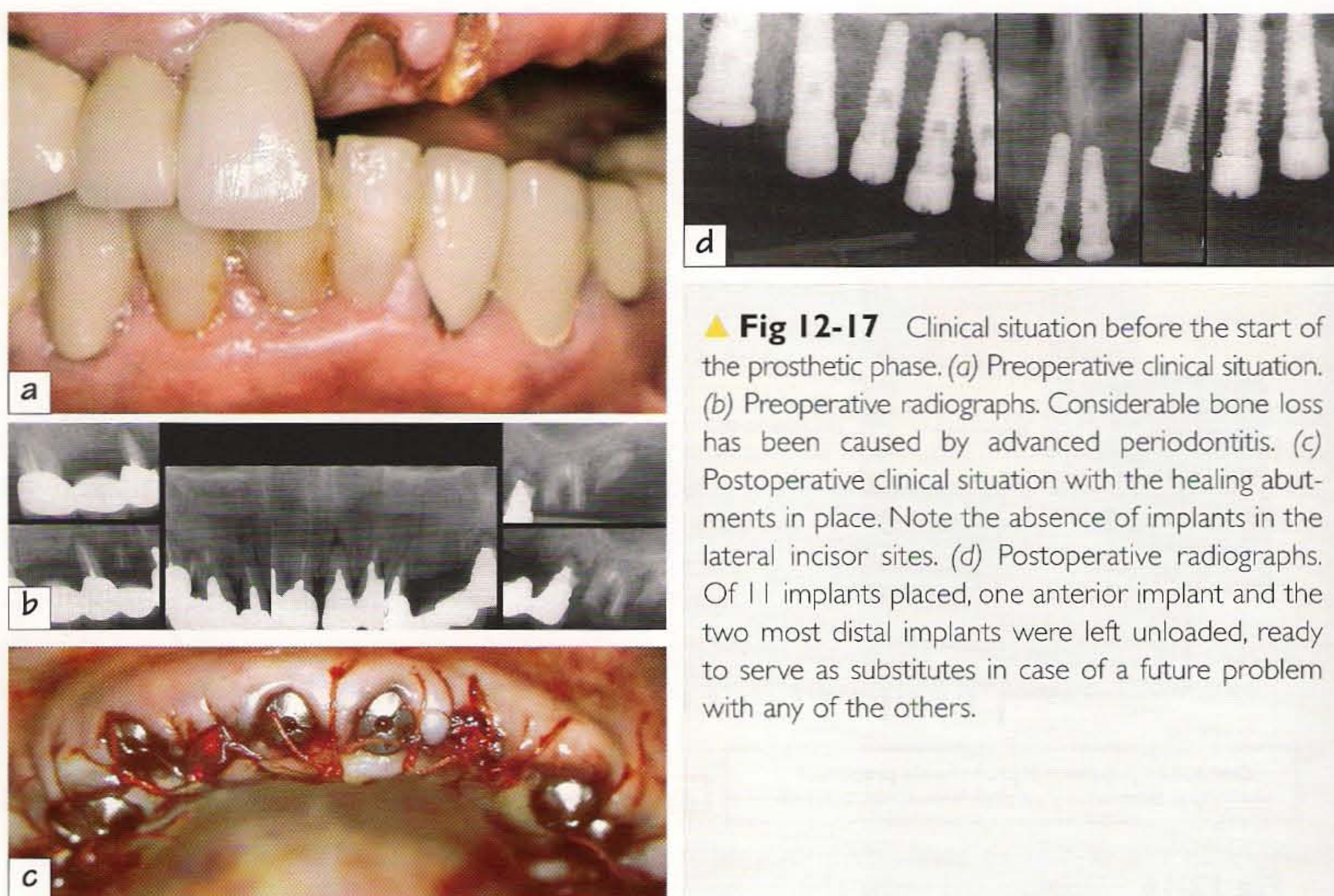
Presurgical and surgical phases

These stages described earlier in the chapter, are the same for all treatment options. The prosthetic phase is carried out in accordance with option 3.

Case history

All of the patient's teeth were affected by advanced periodontitis and their prognosis was poor (Figs 12-17a and 12-17b); they had to be extracted. As a general rule, the most posterior teeth, even if they have to be removed, are retained for as long as possible, until the end of the prosthetic phase. They provide a good indication of vertical dimension, facilitate placement of the surgical guide, and constitute landmarks for establishing the interocclusal relationship. In this case, however, the remaining posterior teeth occupied sites that were needed for implants.

The surgeon placed 12 implants in extraction sites. Nine implants were slated to be loaded immediately. One anterior and two posterior implants were left unloaded as security implants, in case an active implant were to fail at a later date.



▲ **Fig 12-17** Clinical situation before the start of the prosthetic phase. (a) Preoperative clinical situation. (b) Preoperative radiographs. Considerable bone loss has been caused by advanced periodontitis. (c) Postoperative clinical situation with the healing abutments in place. Note the absence of implants in the lateral incisor sites. (d) Postoperative radiographs. Of 11 implants placed, one anterior implant and the two most distal implants were left unloaded, ready to serve as substitutes in case of a future problem with any of the others.

All of the implants demonstrated good primary stability of more than 35 Ncm. The surgeon screwed the healing abutments in the implants, readying them for loading (Figs 12-17c and 12-17d).

Provisional prosthetic phase

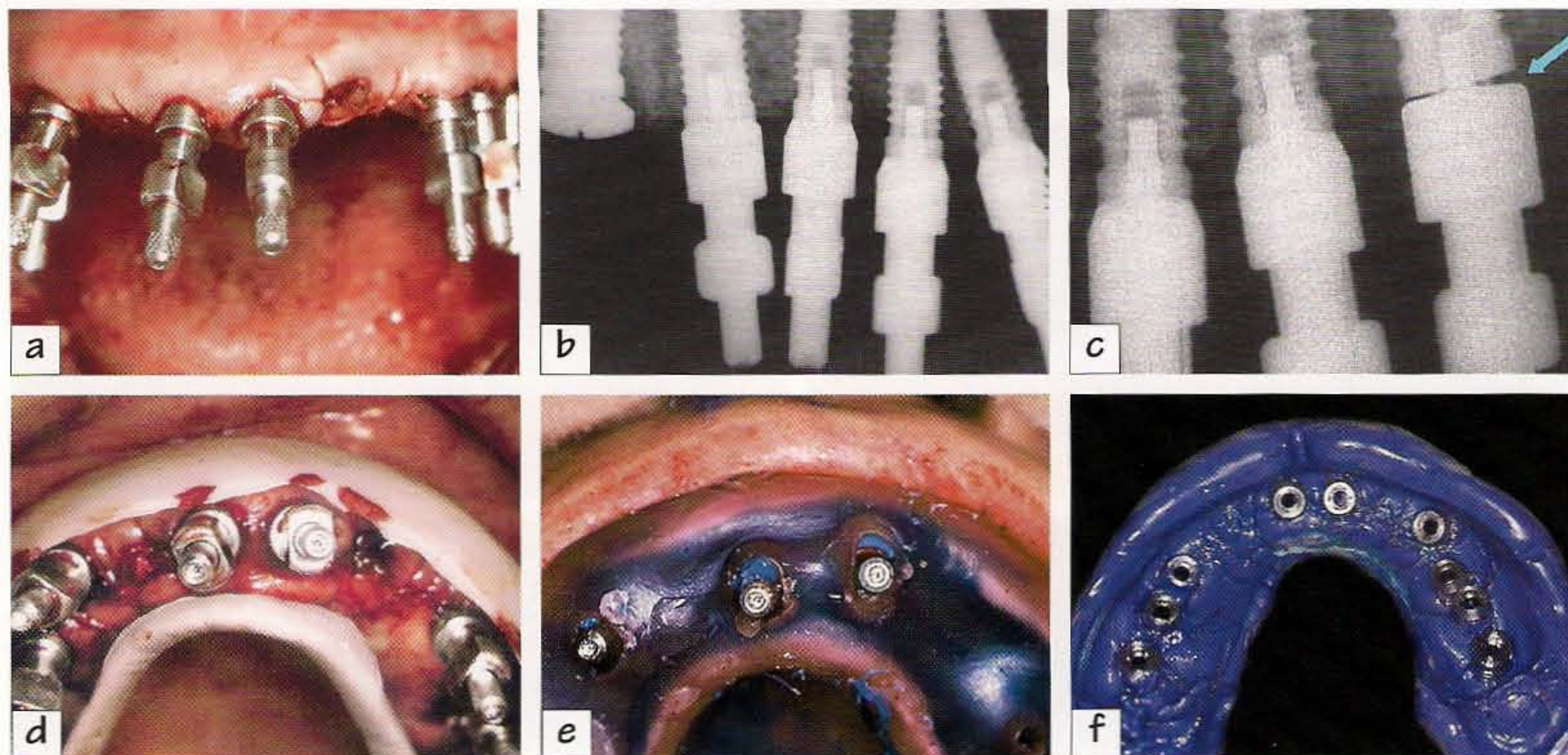
Reminder

It is recommended that the prosthesis be reinforced with a cast metal bar to compensate for the limited acrylic resin mass of the prosthesis and for the bone quality of the maxilla, which is not as supportive as that in the mandible. The few failures the authors have experienced have resulted from fracture of the prosthesis.

Impression

The patient arrives at the prosthodontic office with the healing abutments in place (see Fig 12-17c). The prosthodontist removes them and places impression copings (Fig 12-18a). When external connection implants are used, a radiograph is indispensable at this stage to verify the accurate seating of these copings (Fig 12-18b). Inaccurate seating must be corrected and checked again with another radiograph (Fig 12-18c).

The individualized impression tray is tried in the mouth and any contacts made with the copings are eliminated (Fig 12-18d). A wax sheet (Fig 12-18e) or a piece of tape is placed over the opening of the tray to prevent extrusion of impression material when the impression is taken. The prosthodontist first covers the impression copings with impression material and then proceeds with the pick-up impression. When the material has polymerized, the screws of the copings are located and removed; they are replaced by the healing abutments.



▲ **Fig 12-18** Impression procedures. (a) Attachment of the impression copings directly on the implants. (b) Control radiograph, essential for implants with an external connection. (c) Control radiograph revealing the poor seating (blue arrow) of one of the copings. (d) Try-in of the impression tray in the mouth. All contact with the copings must be eliminated. The height of the tray is also assessed. A wax sheet is placed over the tray to prevent diffusion of the impression material during polymerization. (e) Impression still in the mouth after polymerization. The screws are located and removed. Openings were made in the wax sheet after the impression set. (f) Finished impression. Nine implants will be immediately loaded.

The impression, accompanied by an interocclusal wax bite, is sent to the laboratory to be poured as a working cast carrying implant analogs (Fig 12-18f).

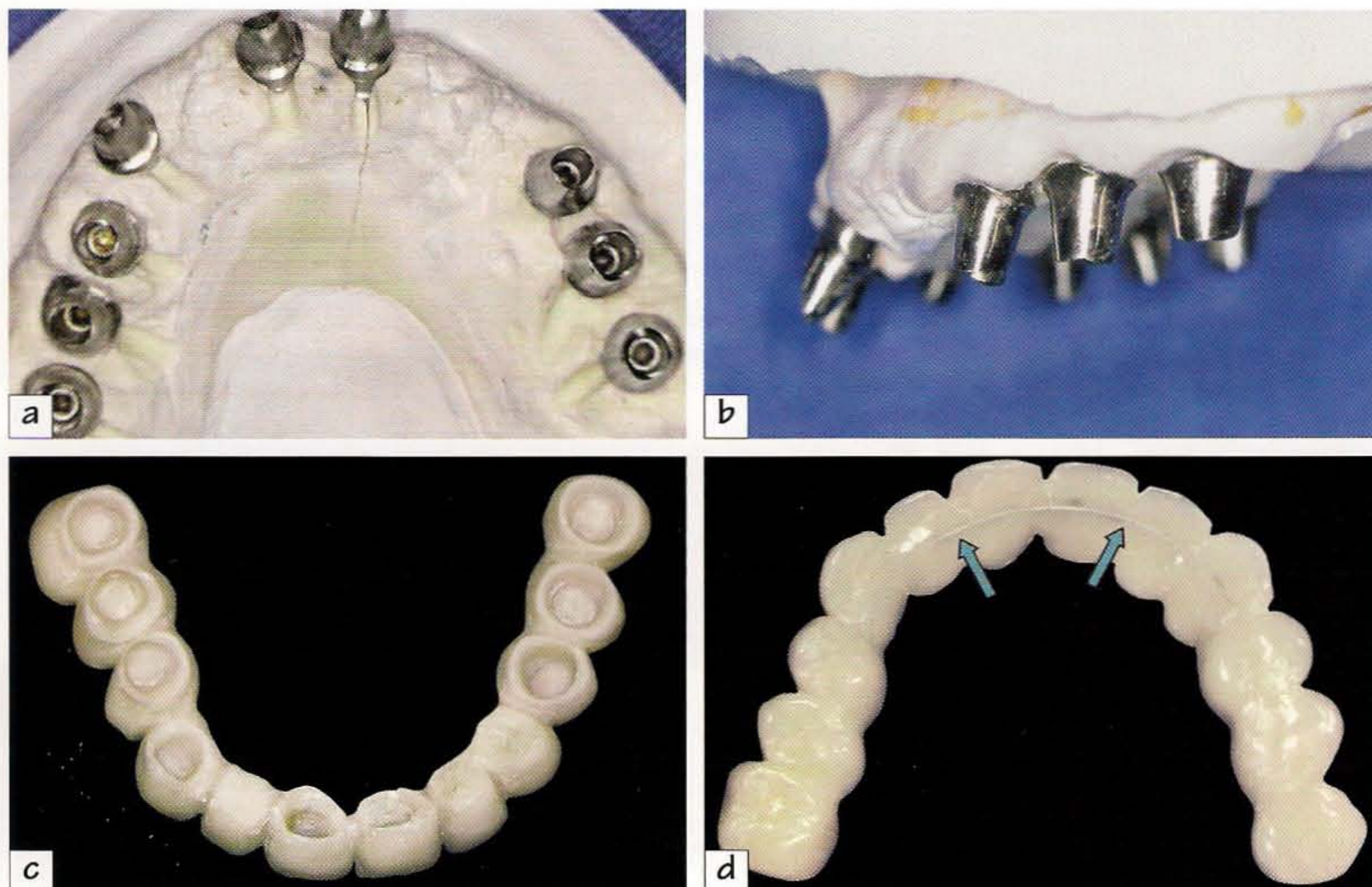
Laboratory procedures

When the working cast is ready, Gingihue titanium abutments (Biomet 3i) are selected and placed. In this case, all of them were straight and had neck height of 2 mm. The general form of the abutments and their cervical margins are prepared on the cast (Figs 12-19a and 12-19b). In this case, the divergence between the anterior and posterior abutments (see Fig 12-19b) did not interfere with the fabrication of a well-fitting cemented complete-arch prosthesis. The prosthesis was made to fit on the abutments (Fig 12-19c). Metal reinforcement was added to it (Fig 12-19d), although a cast framework would have been preferable.

Delivery of prosthesis

The prosthesis is ready to be cemented within 48 to 72 hours. The patient arrives in the prosthodontic office with healing abutments in place (Fig 12-20a). These are replaced by the titanium abutments made by the laboratory; there is no appreciable bleeding during the procedure (Fig 12-20b). The provisional prosthesis is cemented to the abutments with temporary cement; excess cement is removed meticulously (Fig 12-20c).

The occlusion is adjusted so that stresses are evenly distributed throughout the provisional prosthesis (Figs 12-20d and 12-20e). The patient's smile line in this case was low, and limited gingival recession could be tolerated. However, depending on the status of soft tissue healing and the esthetic outcome at the 6-month follow-up visit, a gingival graft could be required.



▲ **Fig 12-19** Fabrication of the cemented provisional complete-arch prosthesis. (a) Gingihue titanium abutments trimmed and screwed into the working cast. (b) Lateral view of the abutments on the working cast. Note the divergence in angulation between the anterior abutments and the posterior abutments. The laboratory will nevertheless be able to construct a one-piece complete denture that can be cemented. (c) Interior surface of the provisional prosthesis, which will be seated on nine implants without any distal extension. (d) Occlusal view of the provisional prosthesis. A metal bar (blue arrows) reinforces this acrylic resin prosthesis. (Prosthesis by Dr E. Cohen.)

Control radiograph

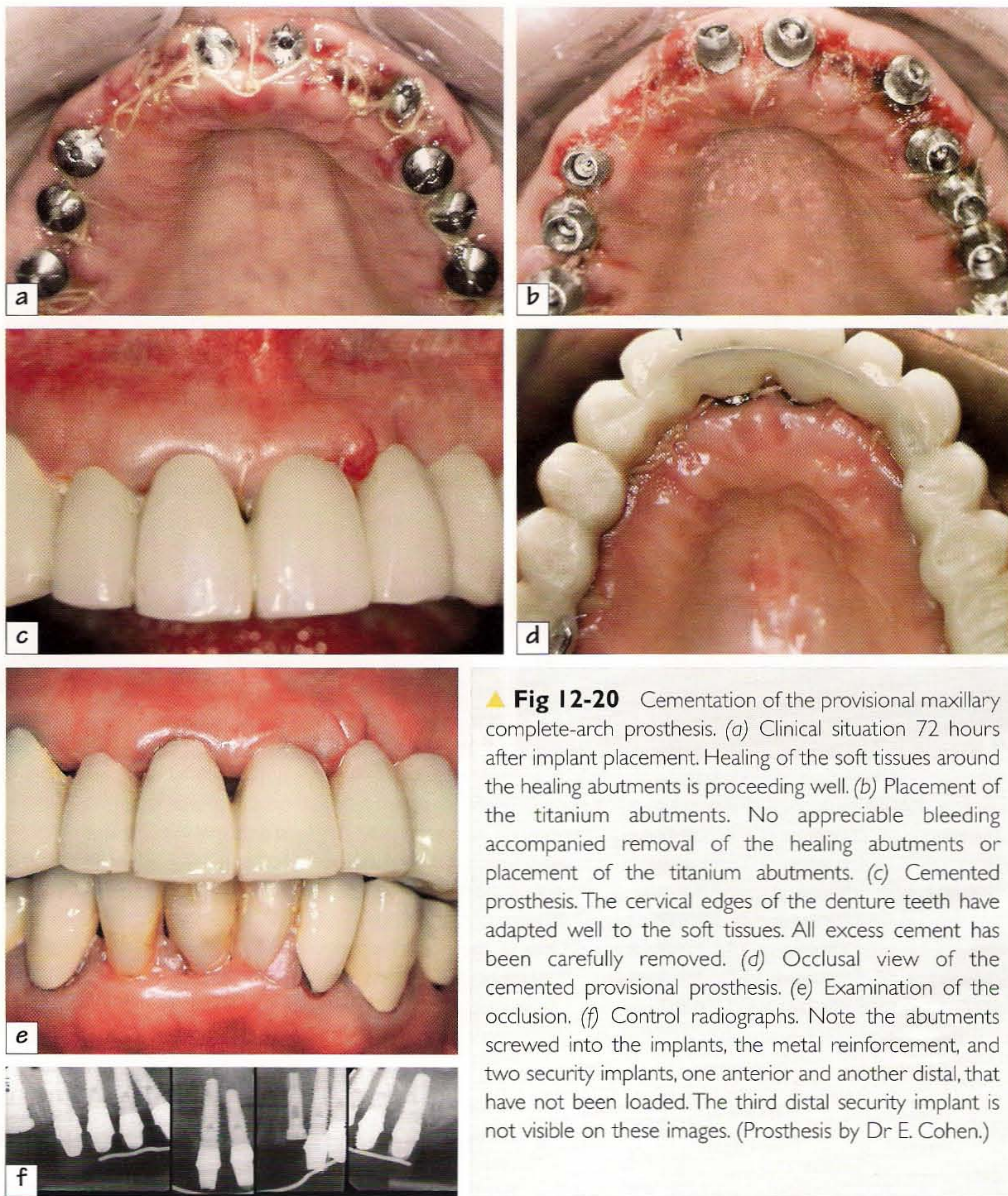
A radiograph is taken at the end of the visit (Fig 12-20f). The image will serve as a baseline reference to evaluate bone status over time.

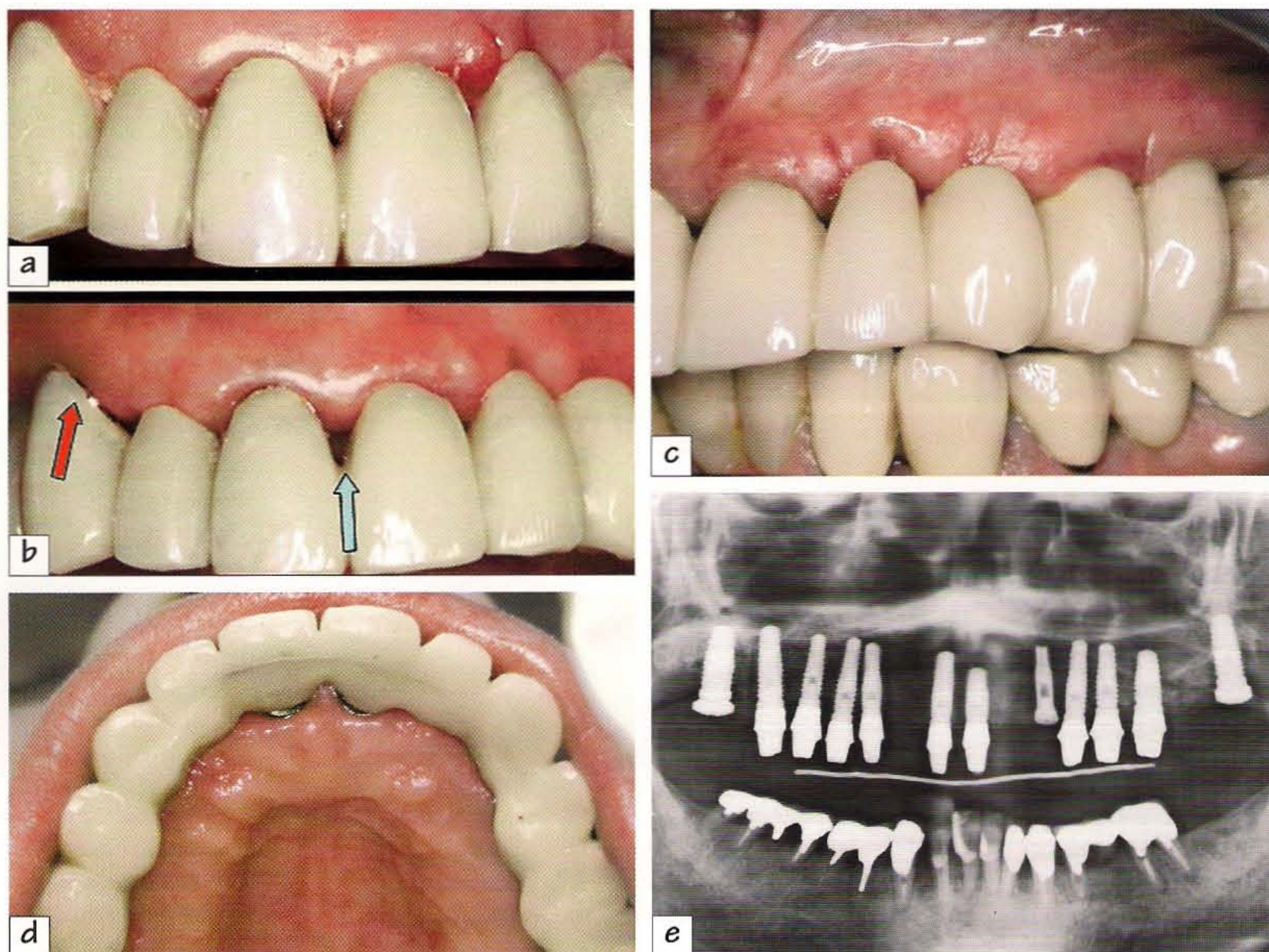
Follow-up

The osseointegration period coincides with the time needed for bone healing and for maturation of the soft tissues. During this process, gingival recession can greatly vary from patient to patient. The abutments may become uncovered, and a metal line may appear above the gingival margin. The extent of gingival recession is a function of local conditions, including the quality and the quantity of the soft tissues, positioning of the implants, and the relationship of the implants to the osseous structures.

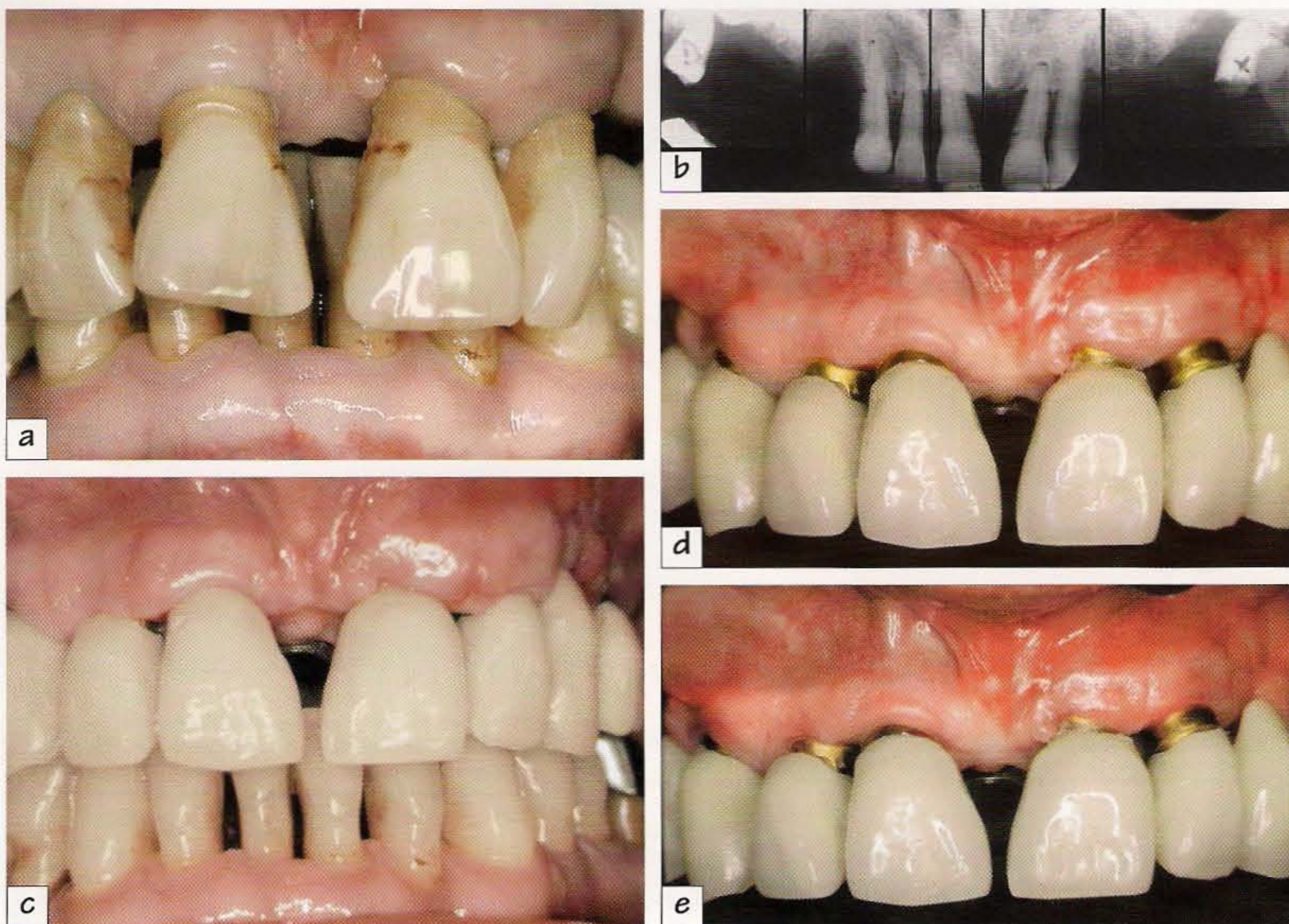
Because the option of a cemented provisional prosthesis is chosen to meet esthetic demands, the changes in gingival appearance over time must be followed with close attention.

Figure 12-21 shows the condition of the patient's soft tissues 3 months after cementation of the prosthesis. The gingival recession was moderate and basically limited to a retreat of the papillae, particularly between the incisors. At that point, the gingival status had stabilized and was expected to remain unchanged over the next months. In other cases, however, gingival recession is more pronounced (Fig 12-22). The reasons for these differing responses have not yet been established with certainty.





▲ **Fig 12-21** Cervical changes 3 months after cementation of the provisional prosthesis. (a) Immediately postoperative condition of the soft tissues. The interincisal papilla is edematous and the cervical margins of the crowns of the anterior teeth seem to be well adapted. (b) Condition of the soft tissues 3 months later. Both the interincisal papillae and the gingival margin exhibit slight recession (*blue arrow*). The gingival recession around the right canine is moderate (*red arrow*). (c) View of the left side. The gingival margins of the prosthesis are still covered by gingival tissue. (d) Occlusal view of the cemented provisional prosthesis. (e) Panoramic radiograph at 3 months. Note the metal-reinforcement bar, the loaded implants, and the three security implants. (Prosthesis by Dr E. Cohen.)



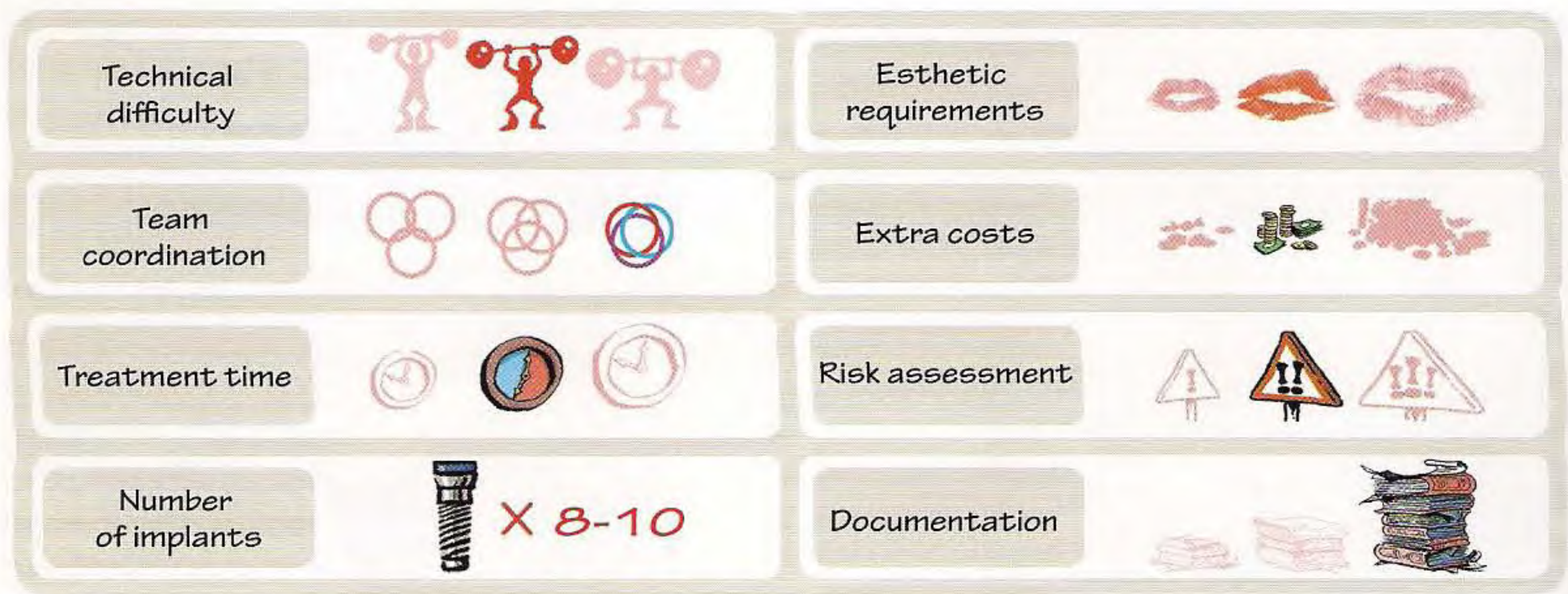
▲ **Fig 12-22** Changes over a 6-month period in the cervical margins of the soft tissue around a cemented provisional prosthesis in a patient with a thin biotype. (a) Preoperative clinical situation. (b) Radiographs of the remaining teeth. All teeth exhibited severe bone loss resulting from advanced periodontal disease and had to be extracted. (c) Clinical situation 1 week after cementation of the prosthesis. The cervical margins of the crowns are well covered by gingival tissue. With the use of a metal framework, it was possible to satisfy the patient's wish to reproduce her initial anterior diastema. (d) Clinical situation 3 months after cementation. Gingival recession around the implants is pronounced, varying from 1 to 3 mm. (e) Clinical view after 6 months. The soft tissue level has stabilized and is unchanged from its 3-month position. (Prosthesis by Dr M. Rohr.)

Prosthetic phase: Treatment option 4

Cemented provisional prosthesis placed within 72 hours after surgery; final abutments and the prosthesis are prepared in the laboratory.

Reminder

- This option is chosen when, for a cemented prosthesis, the principal determinant of treatment is the esthetic needs of a patient with a thin periodontal biotype.
- In this approach, final abutments, made of titanium or zirconia, are placed immediately with no plan to remove them. A fixed prosthesis is fabricated and cemented within 72 hours after implant placement.
- If gingival recession is present, the prosthodontist reshapes the cervical margins of the final abutments at chairside because they are not removed. With the abutments in place, the prosthodontist takes an impression and sends it to the laboratory for fabrication of the final prosthesis.



▲ **Fig 12-23** Key information for treatment option 4.

Key information for treatment option 4

Figure 12-23 summarizes the key aspects of prosthetic treatment in accordance with treatment option 4.

Technical difficulty is average

The laboratory constructs the prosthesis and can compensate for any divergence of the implants with relative ease by adjusting the abutments. However, the prosthodontist will still have to adjust the occlusion of the prosthesis with precision.

Team coordination is tight

The surgical and prosthetic phases are accomplished in two distinct sessions. The prosthodontist takes an impression immediately after implant placement, and the laboratory constructs the prosthesis as quickly as possible.

Treatment time is average

The surgical and the prosthetic phases are not immediately consecutive. The surgical phase is unchanged and the prosthetic phase is relatively brief. Treatment time includes a 2- to 3-hour appointment for surgery and a 1.5- to 3-hour prosthetic phase. The prosthetic phase is divided into one session for the postsurgical impression procedure and another for delivery of the prosthesis. Time must be spent to meticulously remove excess cement.

Number of implants: 8 to 10

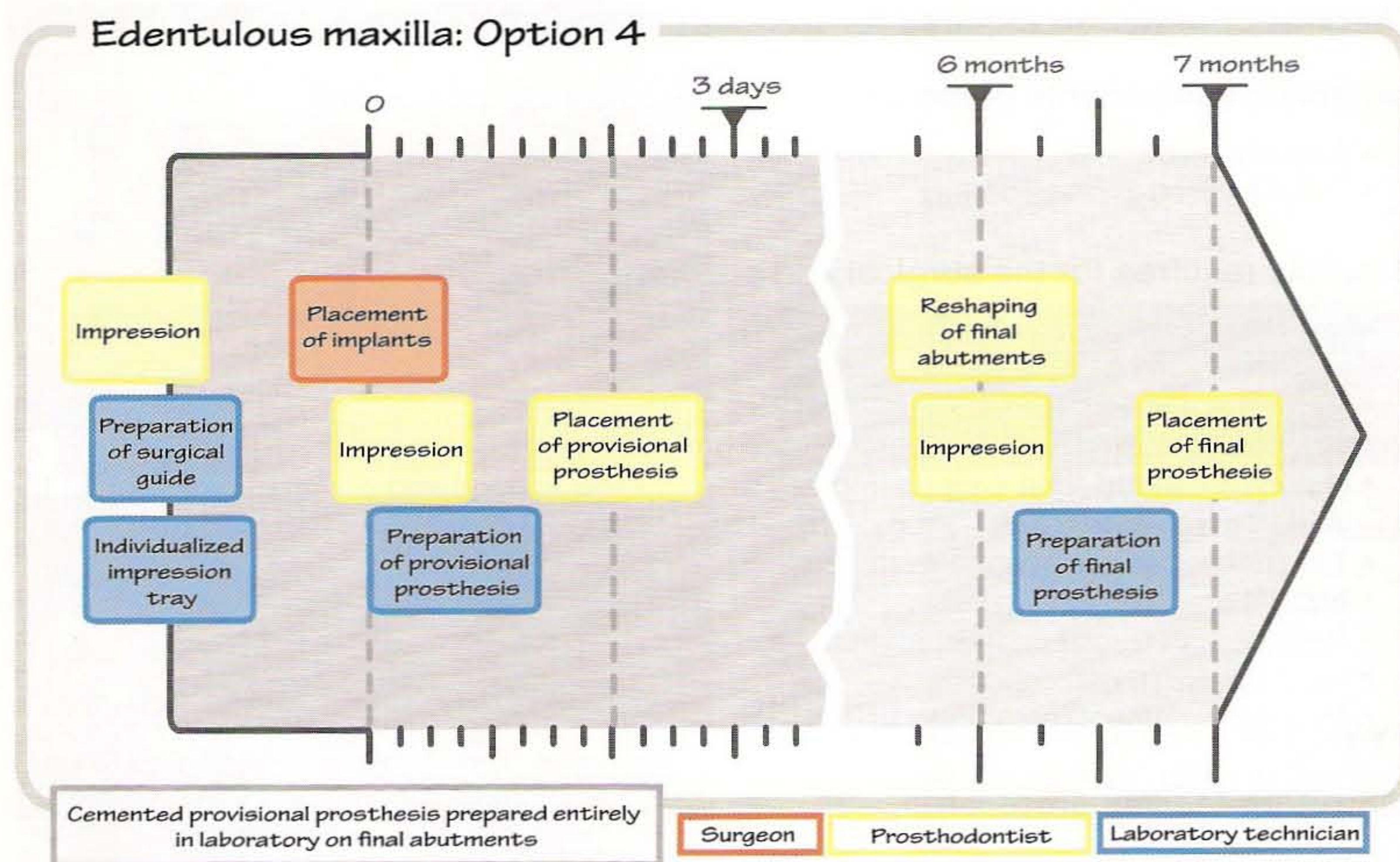
Some authors have suggested that six implants will suffice^{19,20} but with that limited number any implant failure becomes difficult to manage.

Esthetic requirements are moderate

Esthetic considerations are usually moderate for this indication. However, for the best esthetic results, implants must be placed in accordance with the strict rules of implant positioning (see chapter 5).

Extra costs are moderate

The provisional prosthetic phase consists of fabrication of a fixed prosthesis, which entails a certain cost. The prosthesis is fabricated in the laboratory. However, the same abutments are used for the final denture, substantially reducing the overall cost of the prosthetic treatment.



▲ **Fig 12-24** Sequence and timing of steps for treatment option 4. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Additional risk is moderate

Obtaining good primary stability is sometimes a problem, especially when implants are placed in extraction sites. It is preferable to splint implants in a metal-reinforced prosthesis. The esthetic risk has not yet been fully evaluated.

Documentation in the literature is extensive

This indication is the most documented in the literature after immediate loading in the edentulous mandible. However, this particular treatment option has rarely been reported in the literature.

Sequence and timing of steps for treatment option 4

Figure 12-24 illustrates the treatment chronology for option 4:

- The laboratory participates before and after implant placement. Before, the laboratory prepares the surgical guide and the individualized impression tray. Afterward, it prepares the final abutments and constructs the prosthesis.
- The surgeon places the implants in the usual way, carefully following the established protocol.
- The prosthodontist takes an impression after implant placement.
- The laboratory prepares the provisional prosthesis, which will be cemented in the mouth within 72 hours after implant placement.
- After 6 months of functioning, which allows maturation of the soft tissues, the clinical stability of the implants is verified. At this time, the esthetic status is evaluated.
- If any gingival recession has occurred, the prosthodontist reshapes the abutments at chairside to correct the cervical margin.
- The prosthodontist takes another impression of the adjusted abutments.
- The laboratory fabricates the final prosthesis.

Checklist of materials required for treatment option 4

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Individualized impression tray

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Materials needed for a pick-up impression, including enough impression copings for all the implants (prosthodontist)
- Titanium or zirconia abutments (laboratory)
- Implant analogs (laboratory)
- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)
- Temporary cement (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

The presurgical and surgical phases are the same for all prosthetic options. The prosthetic phase is carried out in accordance with option 4.

Case history

The patient, who had a thin periodontal biotype (Fig 12-25a), was concerned about obtaining a good esthetic result. Bone loss was severe and generalized (Fig 12-25b), justifying extraction of all maxillary teeth to allow rehabilitation with an implant-supported prosthesis. After tooth extraction, the patient left the surgeon's office with healing abutments secured to the implants (Fig 12-25c).

Provisional prosthetic phase

A metal-reinforcement bar is recommended for the maxilla (see page 254).

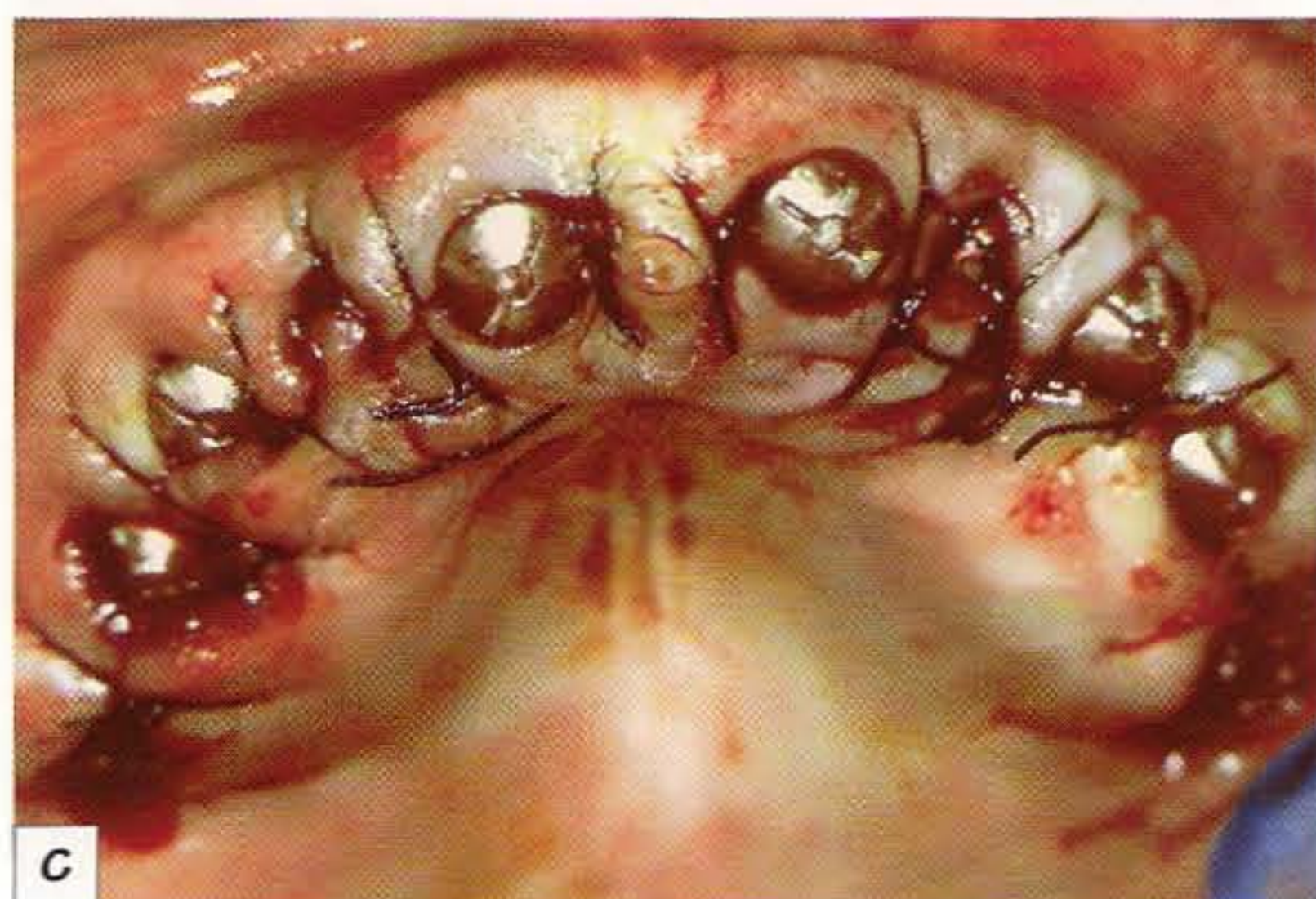
Impression

The impression is taken directly on the implant necks with impression copings screwed in place (Fig 12-26a). The individualized impression tray is then covered with a wax sheet or tape to prevent diffusion of the impression material (Fig 12-26b). After seating the tray, the prosthodontist covers the copings with impression material and then takes the pick-up impression. When the impression material has polymerized, the copings are located and unscrewed. Accompanied by an interocclusal wax bite, the impression is sent to the laboratory.

Laboratory procedures

After the laboratory pours the cast with implant analogs in place, titanium abutments are selected. In this case, the abutments were straight with a neck height of 4 mm. The general shape of the abutments and their cervical margins were prepared (Fig 12-26c). A provisional acrylic resin prosthesis with a reinforcing metal bar and no distal extensions was made over the cast (Fig 12-26d). A half-arch positioning key for the abutments was made in pattern resin and bonded to the abutments with a drop of cyanoacrylate glue.

The crowns of the central incisors, the maxillary right central in particular, were designed with an unusual shape to allow sufficient room for growth of interincisal papilla. When the final prosthesis was fabricated, the shape of the two central incisors was to be modified to provide a harmonious appearance to the anterior papillae (see Fig 12-31f).



▲ **Fig 12-25** Management of an edentulous maxilla according to treatment option 4. (a) Preoperative clinical situation. The patient's periodontal biotype is thin. (b) Preoperative radiographs. Generalized bone loss necessitated prompt extraction of all maxillary teeth. (c) Postoperative clinical situation. Healing abutments have been placed in the eight implants, of the 10 placed, that are to be loaded immediately.

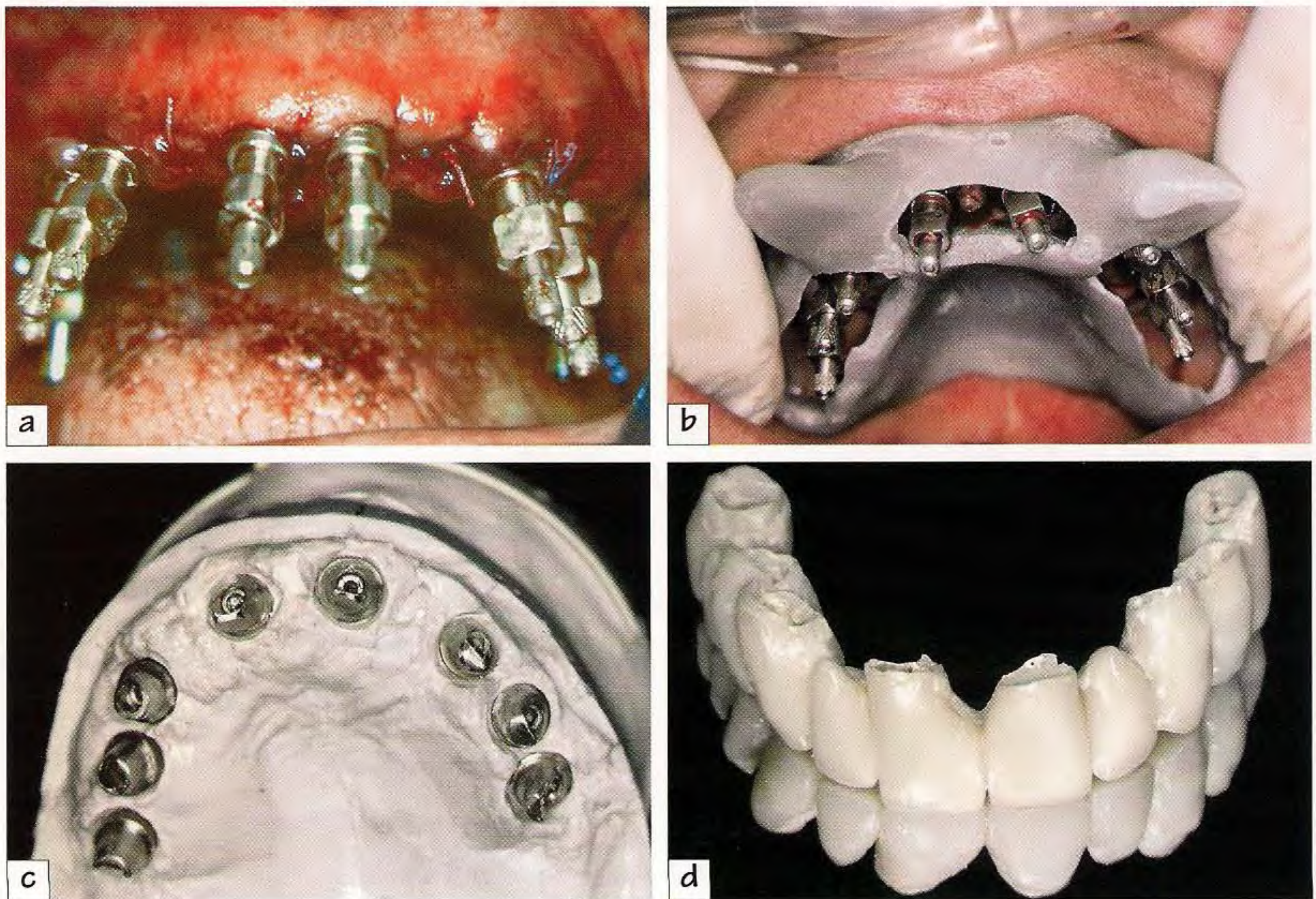
Delivery of prosthesis

The prosthodontist receives the prosthesis and the final abutments with positioning keys within 3 days after surgery.

The patient arrives with healing abutments in place (Fig 12-27a). They are removed, accompanied by a slight amount of bleeding, and replaced by the final abutments, which are screwed in the implants (Fig 12-27b). The prosthodontist places the denture and then cements it (Fig 12-27c). Excess cement is removed with great care (Fig 12-27d). The occlusion is adjusted so that the stresses of function will be evenly distributed throughout the prosthesis (Fig 12-27e); the patient's smile line is assessed.

Control radiograph

A control radiograph taken at the close of this visit (Fig 12-27f) will be used as a baseline to evaluate bone status over time.

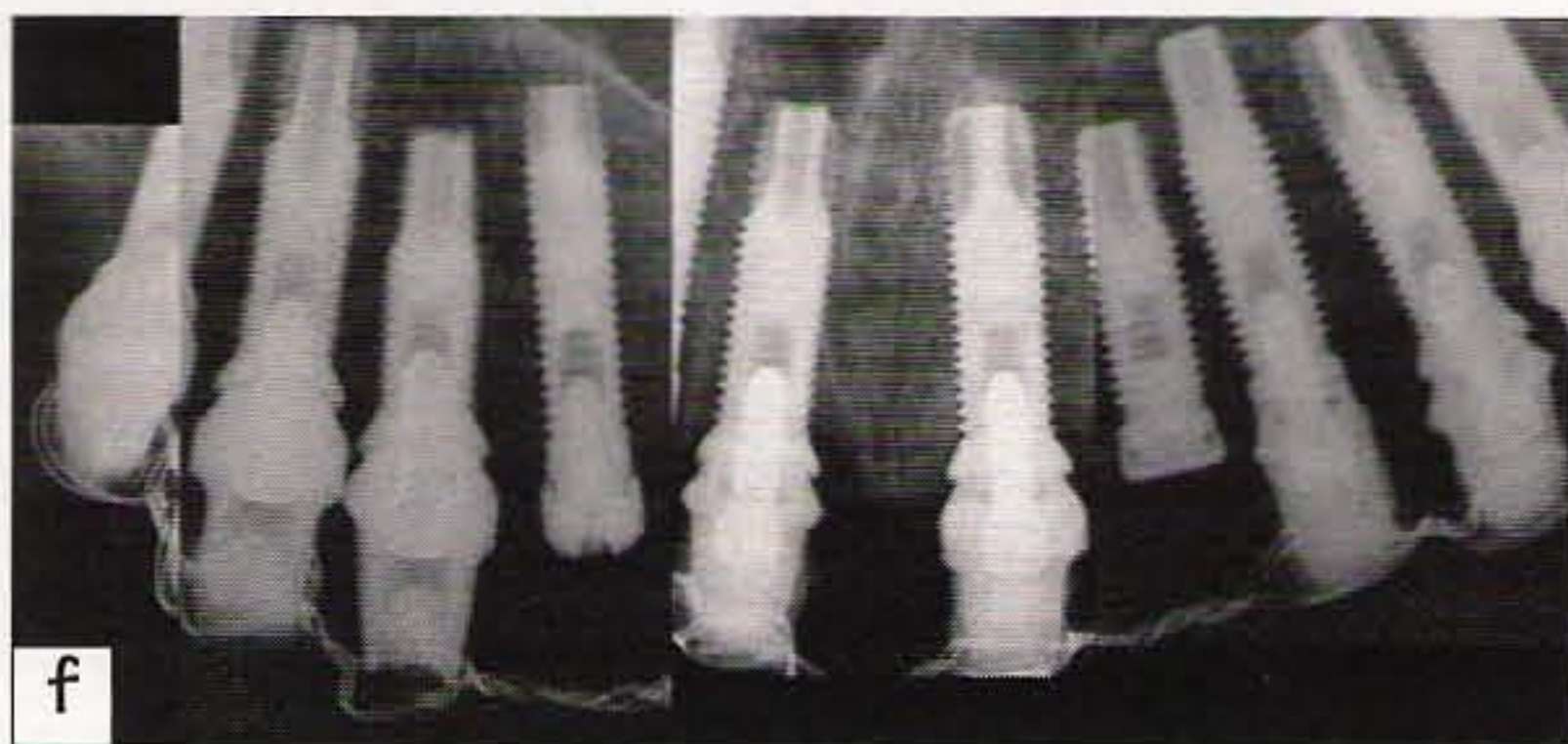
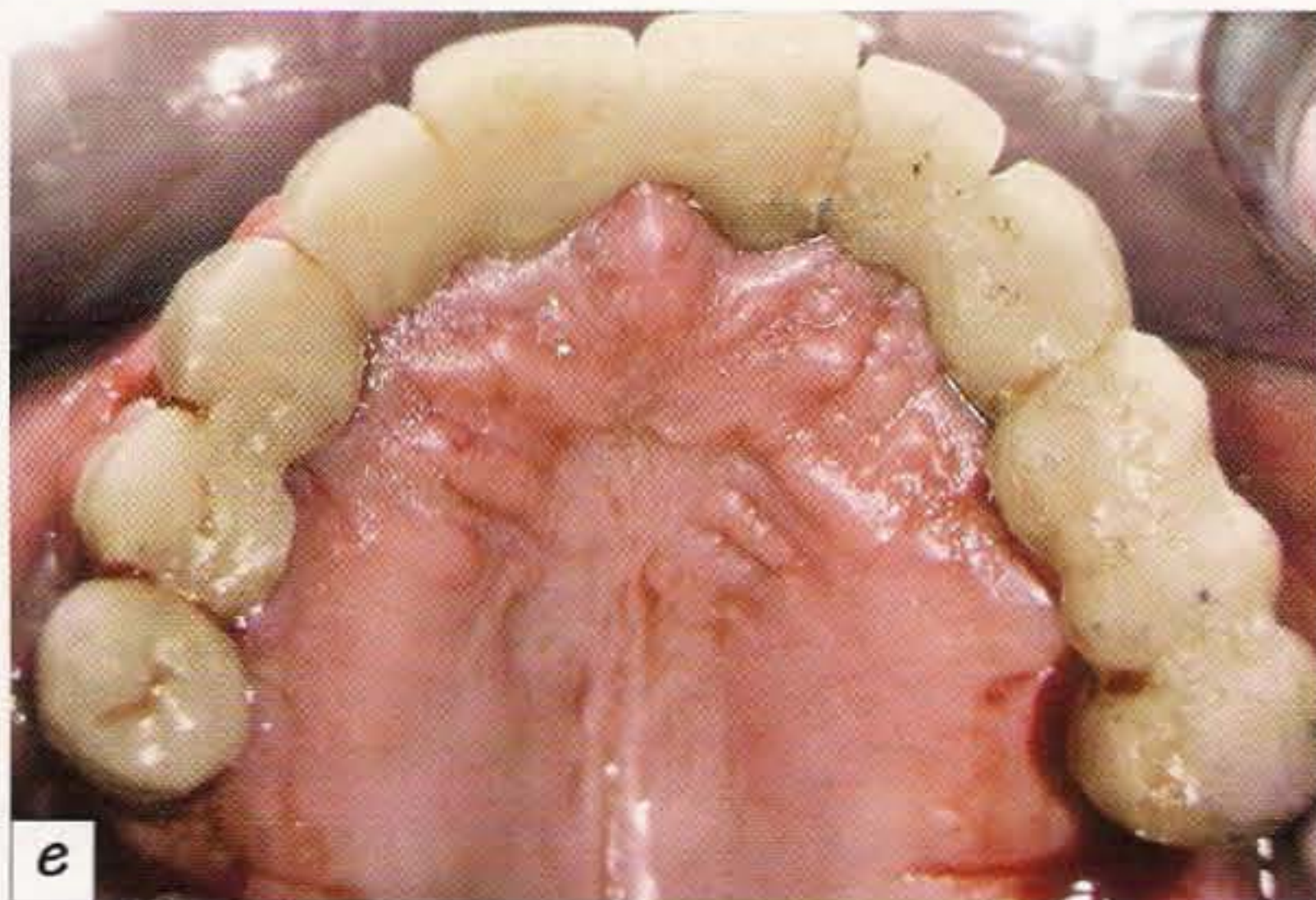


▲ **Fig 12-26** Impression procedures and prosthesis fabrication. (a) Impression copings screwed in the implant necks. (b) Try-in of the impression tray. (c) Preparation of the abutments on the cast poured with implant analogs. (d) Provisional prosthesis ready for cementation. (Prosthesis by Dr G. Audi.)

Control visits

Patients are advised to eat a soft diet for the first 6 to 8 weeks after they receive the prosthesis. Patients receive follow-up examinations:

- At 1 day to evaluate the occlusion and assess the beginning of healing.
- At 10 days to check on soft tissue healing and to remove sutures.
- At 1 month to assess the quality of soft tissue healing and to ensure that the implants are asymptomatic. It is not necessary to check implant stability manually or with Periotest (Medizintechnik Gulden) or Osstell (Osstell). If there is a specific reason for doing so, a screw-retained prosthesis can be unscrewed. This action does not interfere with bone repair, but it is by no means routinely indicated. However, unseating of a cemented prosthesis is definitely contraindicated, because this could exert forces that would interfere with bone repair.
- At 3 months to assess the status of the soft tissue healing and to confirm the absence of symptoms. This is also a good time to take a control radiograph.
- At 6 months to evaluate osseointegration and stabilization of the soft tissues. This assessment will be discussed in more detail later, in the section on the final prosthetic phase.



▲ **Fig 12-27** Cementation of the provisional prosthesis. (a) Clinical situation before cementation. (b) Titanium abutments screwed in place. Bleeding during the replacement of the healing abutments with the final abutments was slight. (c) Prosthesis cemented with temporary cement. The special shape and angulation of the maxillary right central incisor provides more than the usual amount of space for the growth of a papilla between the implants supporting the two central incisors. (d) Excess cement is scrupulously removed from the provisional prosthesis after adjustment of the occlusion. (e) Occlusal view of the provisional prosthesis. Note the presence of metal reinforcement. (f) Control radiographs. The two implants placed in the region of the lateral incisors were left unloaded, beneath the pontics. The objective is to preserve the osseous level to sustain the current soft tissue level. In case of future need, they also could be used as security implants. (Prosthesis by Dr G. Audi.)

The allotted osseointegration period coincides with the period required for bone and soft tissue healing. During this time, gingival recession of varying degrees may develop. Recession is the result of local conditions and is a function of the quality of the patient's periodontal biotype, thin or thick, and the quantity of soft tissues. Recession is also associated with implant positioning in relation to the surrounding bone and surrounding implant-supported structures.

Management of complications

Complications can arise during the surgical phase, the prosthetic phase, or after delivery of the provisional prosthesis. These complications may be common to all options or specific to a given prosthetic option.

Complications during the surgical phase

Complications common to all treatment options

Insufficient primary stability

If primary stability is insufficient (less than 35 Ncm), it is advisable to abandon the implementation of immediate loading. It is, however, possible to consider substituting longer or larger implants for the defective implants. This applies especially to the most anterior and the most distal implants, which will receive the heaviest mechanical burden. The primary stability achieved at these implants must absolutely be 35 Ncm or more.

If the use of an implant of a larger diameter is contemplated, the clinician should verify its compatibility with the local esthetic requirements, that is, conformity with the rules governing distance to adjacent implants and dental units as well as to the buccal plate.

Another solution is to add supplementary implants in adjacent sites. The original implant whose stability is unsatisfactory can be left unloaded in a security role and later might be included as a component in the final prosthesis.

Encroachment on the buccal plate

If the surgeon has miscalculated the orientation of the implant and, while drilling, encroached on the buccal plate, the immediate-loading treatment should be discontinued at that site. The solution would consist of either leaving the implant in place and grafting the cortical plate with a membrane or removing the implant.

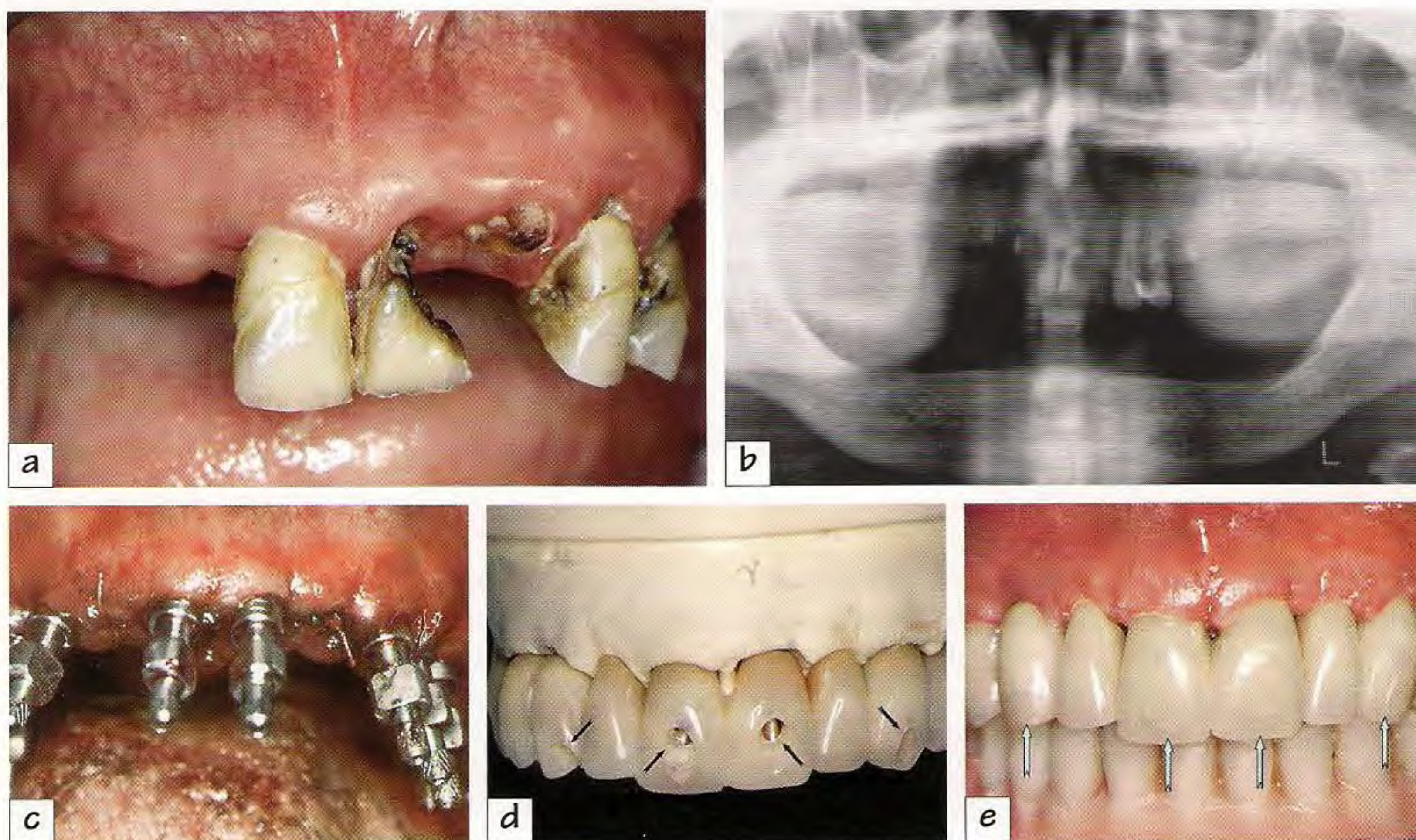
Improper angulation or positioning of implants

These defects in implant placement can lead to horizontal resorption of the buccal plate and seriously detract from the final esthetic results. In such situations, the implant should not be subjected to immediate loading. A bone graft should be considered to restore the missing portion of the buccal plate.

Complications during the prosthetic phase

Complications common to all treatment options

- Hemorrhage during placement of abutments or screw-retained prosthesis.
- Rupture of sutures during placement of prosthesis.
- Incomplete removal of impression material from gingiva. Impression material that remains buried in the gingiva causes inflammation that appears at a later time.
- Failure to achieve passive fit.



▲ **Fig 12-28** Excessive buccal angulation of implants. (a) Preoperative clinical view. (b) Preoperative panoramic radiograph. (c) Impression copings screwed in the implants. (d) Screw access paths of the provisional denture emerging on the buccal surface of the central incisor and canine denture teeth (arrows). (e) Prosthesis placed in the mouth. The screw access openings have been filled with resin composite (arrows).

Complications specific to screw-retained prosthetic options

Excessive buccal angulation of implants

When this happens, the screw access paths will emerge on the incisal edges or the buccal surfaces of the teeth. The prosthodontist can correct this error by switching to a cemented prosthesis, which accommodates the faulty angulation of the implants through compensation in the axes of the abutments. However, the laboratory will have to have titanium abutments available immediately or be able to procure them rapidly.

This complication is illustrated in Fig 12-28. After extraction of the remaining teeth and placement of 10 implants, the prosthetic phase began. The impression copings (see Fig 12-28c) revealed the overly buccal long axes of the implants. The emergence paths of the screws on the incisor and canine denture teeth were on the buccal surface (see Fig 12-28d).

The laboratory did not have the components needed for a cemented prosthesis and delivery of the prosthesis had to proceed promptly. Fabrication of the planned screw-retained prosthesis was continued, although it was not the optimal esthetic solution. The access holes on the buccal surfaces of the denture teeth were masked with resin composite. As disagreeable as this esthetic setback might appear, it can be overcome with relative ease. In this case, the final prosthesis was cemented on abutments that corrected the poor implant orientation.

Pronounced divergence of implants

When this occurs, an impression cannot be taken directly on the necks of the implants, especially those with internal connections. When they diverge, prosthodontists should add IOL transgingival abutments because they increase the tolerance for a lack of parallelism.



◀ **Fig 12-29** Resolution of an angulation problem. A "mixed" final prosthesis, partly cemented and partly screw retained, was fabricated. The anterior segment of the prosthesis is cemented and the posterior is screw retained. (Prosthesis by G. Fournier)

If implants diverge so seriously that neither a screw-retained nor a cemented prosthesis would appear to be feasible, it is still possible to make a prosthesis with mixed retention, cemented in its anterior segment and screw-retained posteriorly (Fig 12-29).

Failure to achieve passive fit

This can result from a faulty impression or some mishap occurring in the laboratory during fabrication of the prosthesis. The prosthodontist will have to take another impression and the laboratory will attempt to obtain a passive fit of the prosthesis on the new cast.

Complications specific to cemented prosthetic options

Incomplete removal of excess cement

Excess cement left in the mouth after placement of a denture can provoke gingival inflammation that will appear at a later time. This risk is particularly high when a prosthesis is cemented on implants placed in extraction sites, because there are more gaps in which the cement particles can become entrapped than there are in healed sites. The prosthodontist should be especially vigilant in removing all debris in these cases to prevent surface inflammation or, worse still, interference with the progress of osseointegration.

Failure to achieve passive fit

This usually results from an inaccurate impression or some laboratory misstep. In general, this problem is easily resolved by an adjustment of the abutments involved, and cementation of the prosthesis can resume.

Complications after delivery of the prosthesis

Complications common to all treatment options

Incomplete removal of impression material from gingiva

Gingival inflammation can be caused by overlooked impression material trapped in the gingival margin.

Fracture of acrylic resin teeth in provisional prosthesis

The prosthodontist's first response to tooth fracture should be to check the occlusion and verify if excessive impact is the cause. The laboratory can readily repair the damage and the prosthodontist can adjust the occlusion to prevent future fracture of the denture tooth.

Fracture of provisional prosthesis

Fracture of the prosthesis is most likely to occur when a metal bar has not been used to strengthen the prosthesis. The prosthodontist should verify the stability of the implants near the fracture site. The broken denture is sent to the laboratory for repair and addition of metal reinforcement. The occlusion is checked again to see if it needs adjustment.

Complications specific to screw-retained prosthetic options

- Loosening of cylinder screws
- Loosening of abutment screws

Complications specific to cemented prosthetic options

- Debonding of prosthesis.
- Incomplete removal of excess cement. Inflammation of the gingiva can result from overlooked residual cement.

Implant failure and alternative treatments

Failure of an unessential implant

When an implant is identified as mobile, immediate action must be taken to prevent horizontal resorption of the bone crest. Usually this means removing the implant (see chapter 8). The implant can be replaced with another implant of larger diameter and, if possible, greater length. However, this new implant must still be compatible with local esthetic requirements, which are a function of the proximity to other dental units and to the buccal plate. The site is prepared by removal of all fibrous tissue. The new implant does not have to be immediately loaded but can be left to osseointegrate in preparation for the final prosthesis; this solution will shorten the overall treatment time.

Alternatively, if a security implant is located near the failed implant, the prosthodontist can remove the prosthesis and take a new impression that includes the security implant. Using the poured cast, the laboratory can make a cylinder or an abutment for the newly utilized security implant.

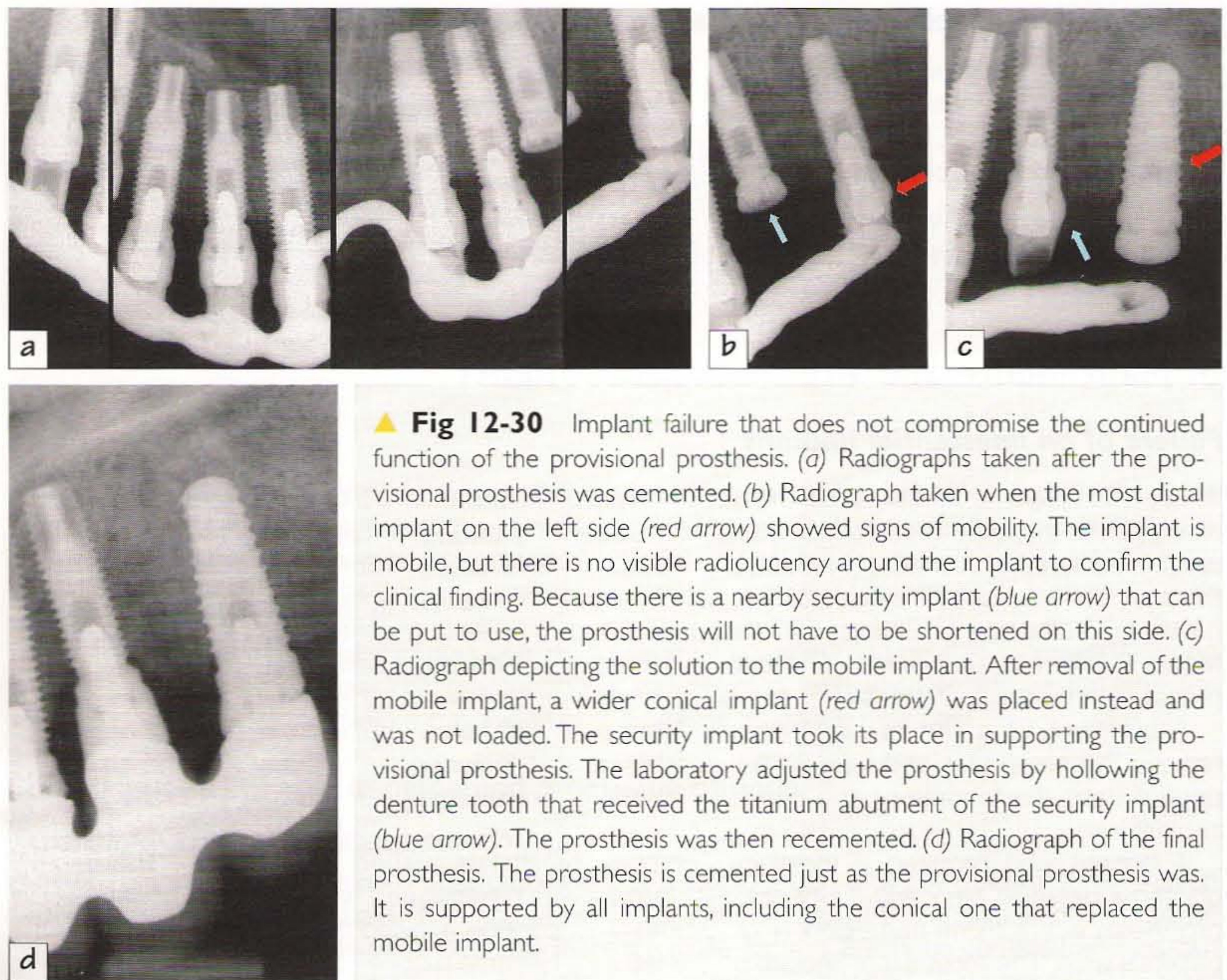
A patient who required a maxillary complete prosthesis wished to reproduce the original diastema between her central incisors. Her maxilla was rehabilitated with a cemented provisional prosthesis with a metal framework (Fig 12-30a). This support allowed the prosthesis to satisfy the patient's wish. The most distal implant on the left side became mobile after 8 weeks of loading (Fig 12-30b). This implant was removed, and a wider conical implant was promptly positioned in the same place (Fig 12-30c). Utilization of a security implant that was located nearby on the mesial side avoided the need to shorten the prosthesis.

Another impression that included the previously submerged security implant was taken. The laboratory adjusted the prosthesis to the new conditions; these steps included hollowing the appropriate tooth of the prosthesis to receive the titanium abutment of the security implant. The provisional prosthesis was then cemented over all the implants, including the new one (see Fig 12-30c). The final cemented prosthesis included the new implant placed in the site of the failed mobile implant (Fig 12-30d).

Failure of multiple implants

When more than one implant fails, compromising the function of the provisional prosthesis, the mobile implants are removed. They can be replaced, after their sites have been prepared again and cleaned of all fibrous tissue, with implants of wider diameter and, if possible, greater length. The replacement implants must still be compatible with the esthetic requirements of the site, primarily conforming to the rules for proper distancing from adjacent dental units and the buccal plate. If their primary stability is satisfactory (greater than 40 Ncm), they can be loaded immediately, and the provisional prosthesis can be returned to function. Alternatively, additional implants can be placed in adjacent sites and the provisional denture can be refashioned to accommodate them.

If acceptable primary stability cannot be obtained through either of these solutions, a fixed provisional prosthesis is no longer feasible. The sites should be left to heal for 2 to 3 months and then new implants should be placed. In such cases, the prosthodontist makes a removable provisional denture for the patient.



Final prosthetic phase

Considerations common to all treatment options

The final prosthetic phase can begin 6 months after placement of the provisional prosthesis, a delay that should allow the soft tissues to complete their maturation.

Implant osseointegration is verified both radiographically and clinically. Radiographically, the absence of a dark, radiolucent area around the implant indicates successful osseointegration. Clinically, the implant is:

- Tested manually for mobility
- Assessed for the presence or absence of any clinical sign such as pain or local inflammation
- Tested with the application of a 20-Ncm countertorque
- Assessed with the Periotest or Osstell to measure implant stability (see chapter 4)

Esthetic considerations

Final prosthesis on “provisional” abutments or cylinders

After removing the provisional prosthesis, the prosthodontist determines the extent of soft tissue recession. When it is limited, a new impression of the healed sites is taken without difficulty. The laboratory constructs the final prosthesis in conformity with the new parameters, emergence profiles adjusted accordingly. When the recession is more pronounced, a gingival graft should be considered.

The final prosthesis can be cemented or screw retained; the selection of retention follows the principles discussed in chapter 7. To prepare the final prosthesis, the prosthodontist takes an impression in the traditional manner on the implant necks and sends it to the laboratory for fabrication of a ceramometal or an all-ceramic final prosthesis.

Final prosthesis on “final” abutments

To avoid disturbing the mucoepithelial attachment that has been formed and stabilized for 6 months, and thereby provoking gingival recession, the final abutments that supported the provisional prosthesis are not unscrewed.

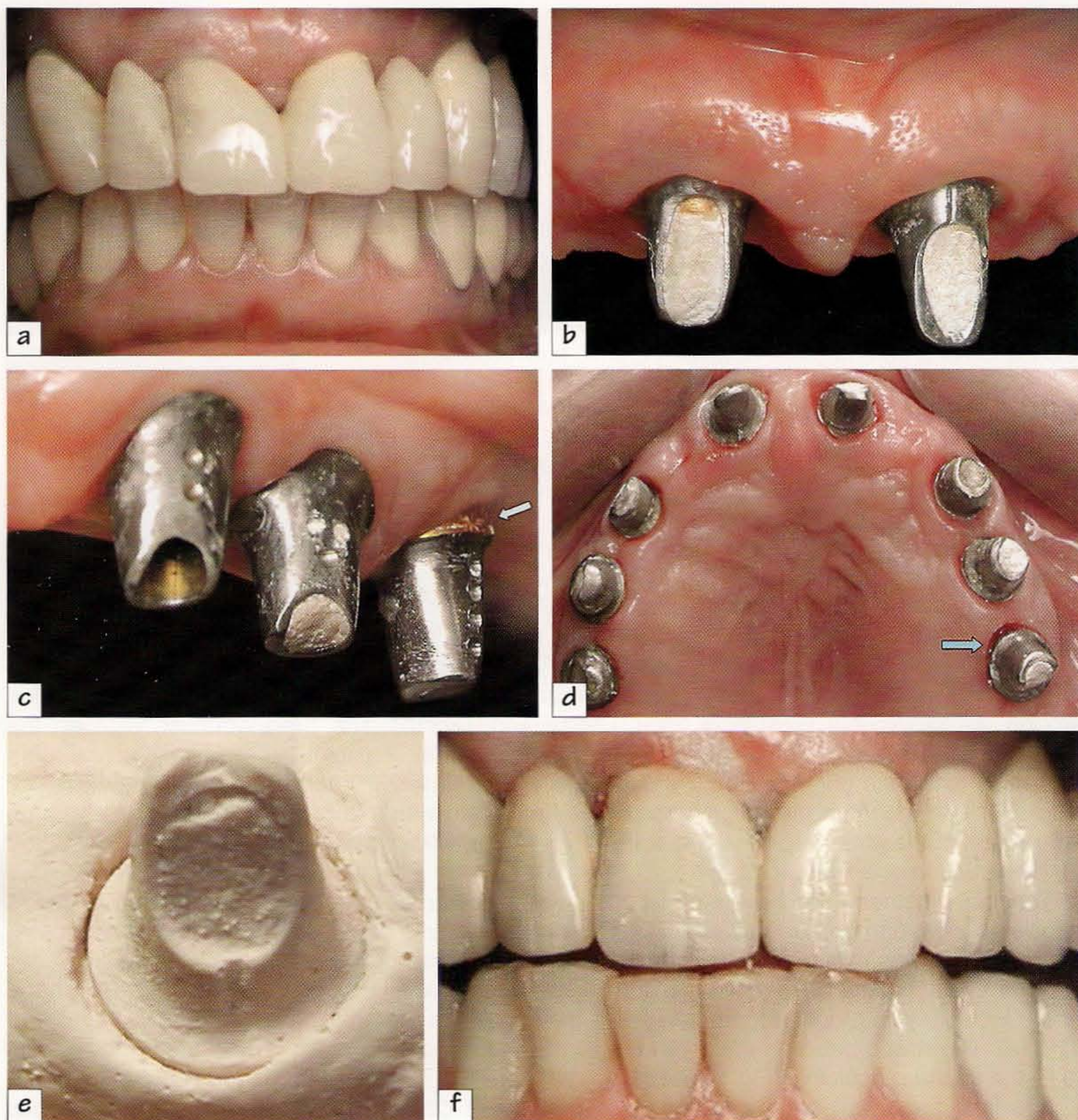
When gingival recession is present, the prosthodontist reshapes the cervical margins of the abutments in the mouth. An impression is taken following the principles used for prosthetic restorations supported on natural teeth. The final prosthesis is then fabricated and placed in the patient's mouth, and the occlusion is adjusted in the usual way.

The final prosthetic phase for the patient who was depicted in Figs 12-25 was begun 6 months after immediate loading of the implants. In the anterior segment, there was no gingival recession around the provisional prosthesis (Figs 12-31a and 12-31b). The prosthodontist removed the prosthesis and checked the gingival contours. In the posterior region, the margins of one abutment had to be reshaped (Fig 12-31c). It was trimmed in the patient's mouth down to the new gingival level (Fig 12-31d). After the gingival sulcus was retracted with a cord, the prosthodontist took an impression of the abutments and a wax bite (Fig 12-31e). The records were sent to the laboratory for construction of a final prosthesis.

The final prosthesis can have a metal framework or be an all-ceramic prosthesis. At this time, a cantilever tooth can be added if necessary, because implants have osseointegrated. In this case, the prosthesis was extended distally by the addition of a premolar crown to the left side.

For the final prosthesis in this case, special care was paid to the interincisal papilla. The shape of the incisors was modified compared with their shape in the provisional (see Figs 12-26d and 12-31a). The space between the central incisors was now closed to exert pressure on the papilla to fill the space completely (Fig 12-31f).

The final prosthesis was cemented with permanent cement. Healing of the gingival sulcus reduced the chance that excess cement would extrude into the soft tissues. However, this does not eliminate the need for careful and meticulous removal of any debris after cementation. The occlusion was properly adjusted, and the visit was completed with a control radiograph.



▲ **Fig 12-31** Fabrication of a final prosthesis on final abutments according to option 4. (a) Provisional prosthesis in place just before the start of the final prosthetic phase. The soft tissues have stabilized and there is no gingival recession in the anterior segment, where esthetics is a prime consideration. (b) Interincisal papilla after removal of the provisional prosthesis. The papilla is healthy and quite substantial. (c) Gingival recession in the posterior area. The most distal abutment is affected. It will have to be reshaped in the mouth to avoid manipulations that would have a deleterious effect on the periodontal attachment that has been maturing for 6 months. (d) Occlusal view after reshaping of the abutment that had been affected by gingival recession (blue arrow). (e) Impression taken directly on the reshaped abutment. (f) Final prosthesis placed in the mouth. The new shape of the central incisors reduces the space available for the central papilla and exerts pressure on it; consequently, the space is entirely filled. (Prosthesis by Dr G. Audi.)

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Chapter 13

TREATMENT OF THE EDENTULOUS ANTERIOR MANDIBLE

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Stuart Molloy*

Immediate loading of implants in the edentulous anterior mandible has rarely been described.¹⁻³ Yet, by rehabilitating this part of the mandible promptly and efficiently, dental practitioners can offer important benefits to their patients. The anterior mandible is often the last remaining dentate area, and rapid replacement of the anterior mandibular teeth restores both support to the lower lip and adequate speech.

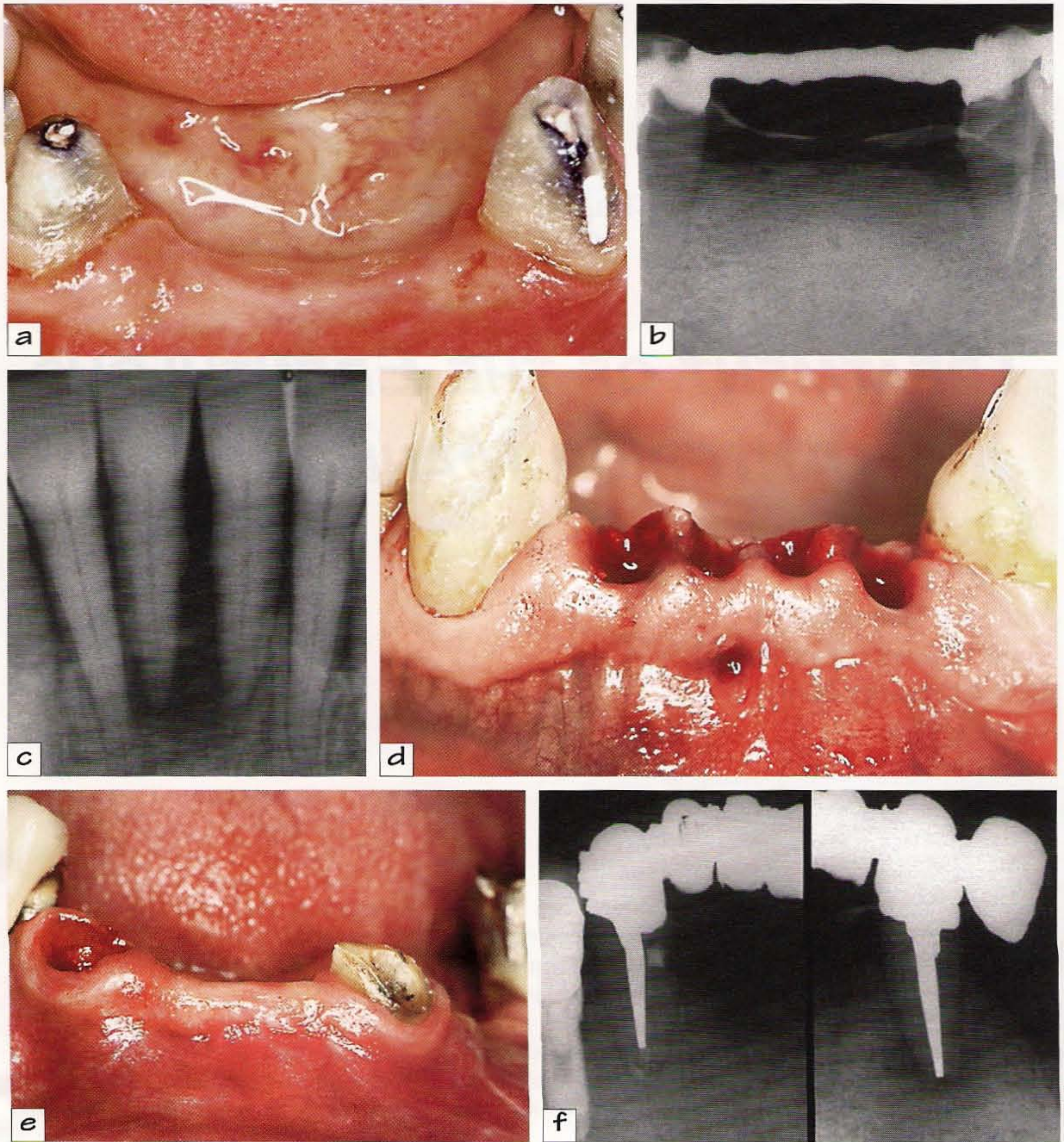
Treatment of this region with the immediate-loading protocol has been presented only anecdotally, despite the lack of biologic, mechanical, or esthetic difficulties associated with this indication. Treatment of the anterior mandible is a good opportunity for clinicians to become familiarized with immediate-loading protocols.

The authors' experience in this area to date has consisted of treating 6 patients with 22 immediately loaded implants that have been functioning for 2 to 3 years, without a single failure. A literature review⁴ of the reported application in the anterior mandible found mention of 37 patients with 105 implants, followed for 1 to 2 years; the average success rate was 99%.

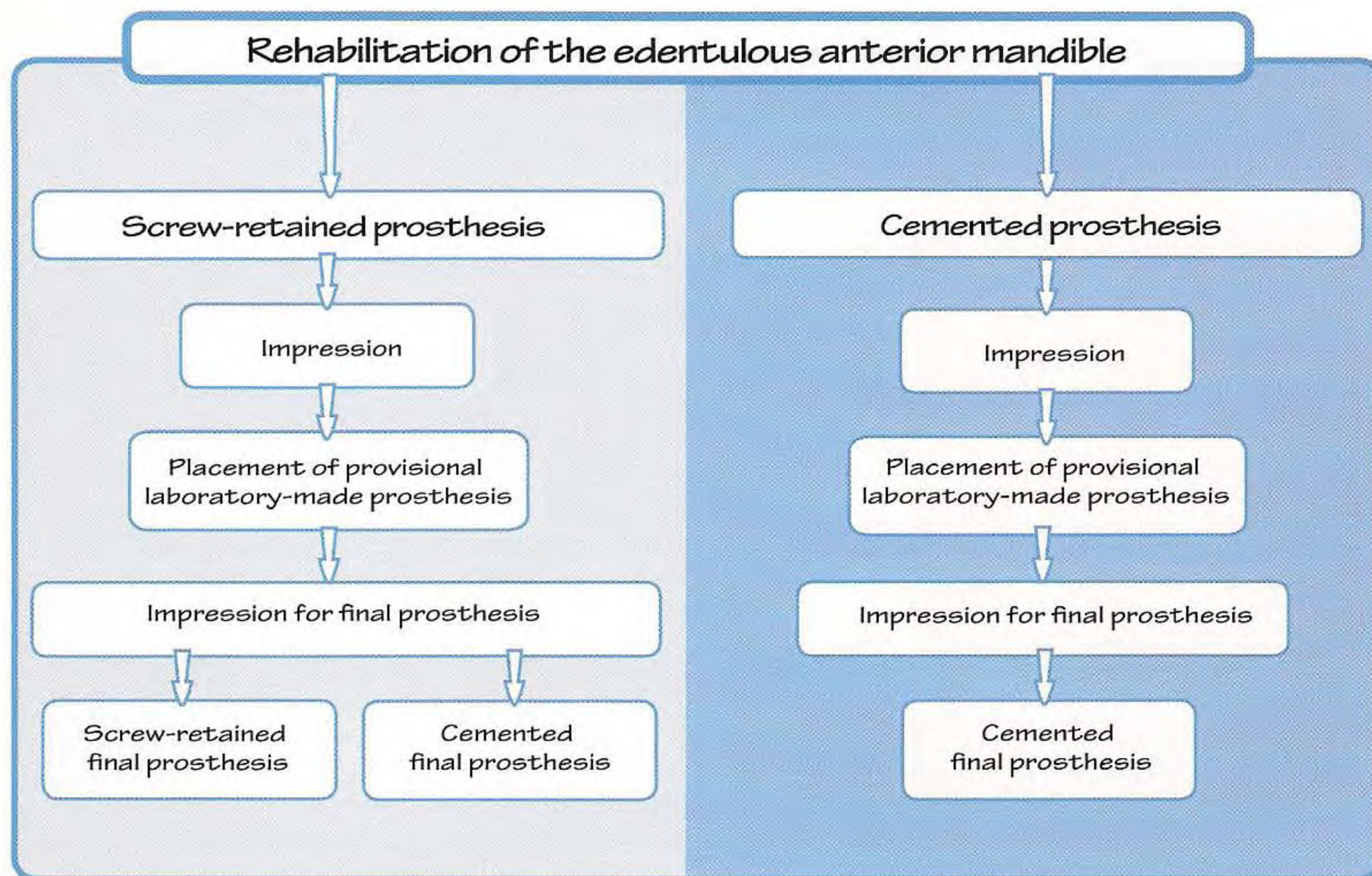
Treatment of the anterior mandible includes:

- Rehabilitation of anterior segments of the mandible that have been edentulous for some time; all implants will be placed in healed sites (Figs 13-1a and 13-1b).
- Rehabilitation of anterior segments of the mandible that are "becoming edentulous" after extraction of hopeless teeth; implants will be placed in extraction sites (Figs 13-1c and 13-1d) or in a combination of healed and extraction sites (Figs 13-1e and 13-1f).

The overall management of these two indications are similar, but the discussion of these options will include their specific characteristics and the particular difficulties that are associated with each.



▲ **Fig 13-1** Clinical conditions included in the term *edentulous anterior mandible*. (a and b) Edentulous anterior mandible that presents only healed sites for implant placement. (a) Clinical view of the edentulous anterior mandibular segment. (b) Preoperative radiograph. (c and d) Edentulous anterior mandible that presents only extraction sites for implant placement. (c) Preoperative radiograph. The remaining teeth have to be extracted. (d) Clinical view after extraction. (e and f) Edentulous anterior mandible that presents with both healed and extraction sites for implant placement. (e) Intraoral view of a mandibular anterior segment that will be edentulous after extractions. (f) Radiographs revealing that the remaining teeth have to be extracted.



▲ **Fig 13-2a** Decision tree showing all treatment options available to rehabilitate the anterior segment of the mandible. These options are common to healed and extraction sites.

▼ Treatment Options

The range of treatment options for the edentulous anterior mandible is outlined in Fig 13-2a in the form of a decision tree with successive decisions nodes. The decision tree is similar for both healed and extraction sites.

Edentulous anterior segments of the mandible are treated the simplest way when the prosthesis is constructed in the laboratory; therefore, options for chairside preparation will not be discussed in this chapter. However, should the need arise for any reason, the provisional prosthesis can be constructed at chairside in the same way as the provisional prosthesis for the anterior maxilla (see chapter 11) or the posterior regions of the mandible or maxilla (see chapter 14).

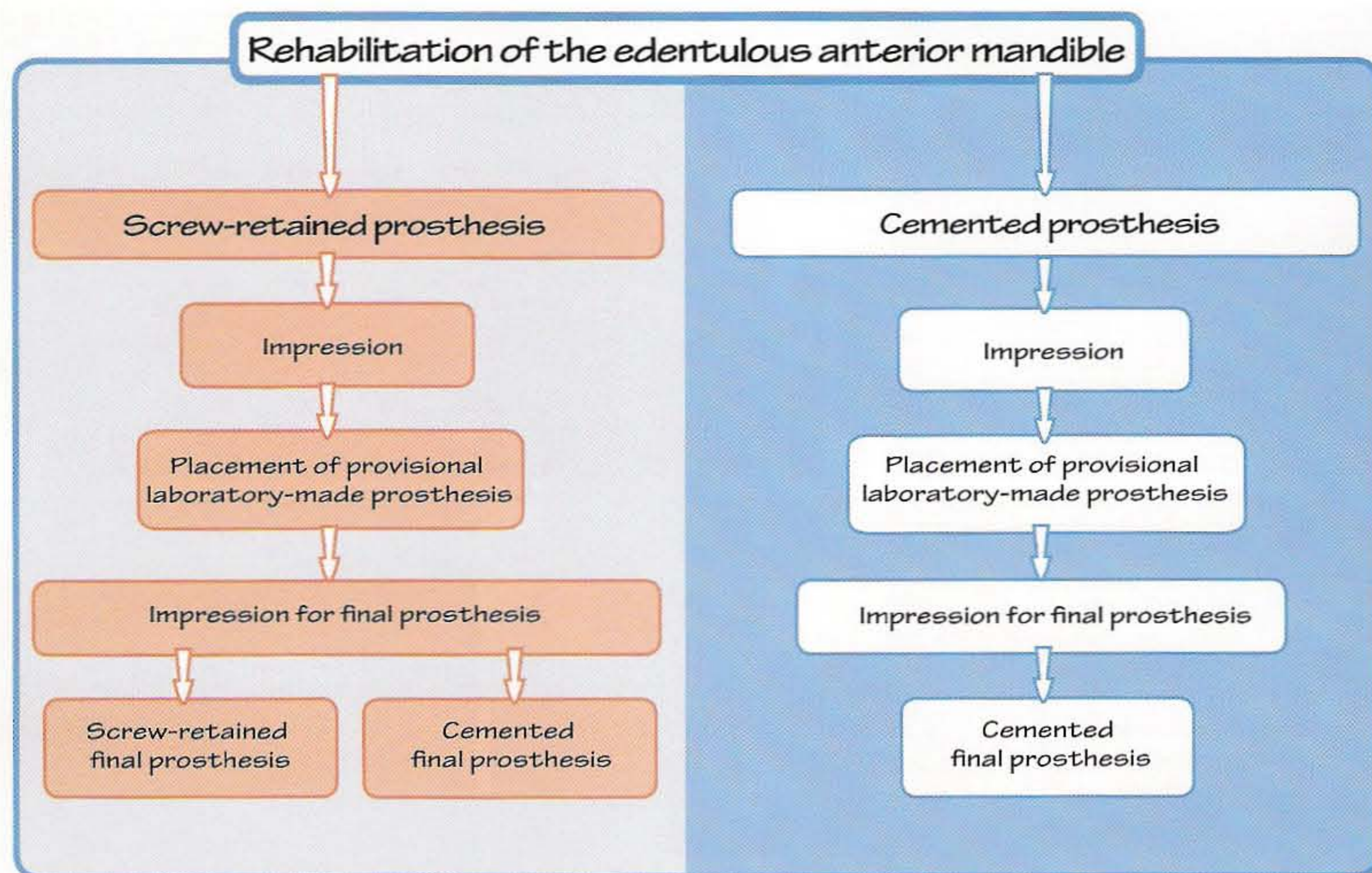
Decision nodes

First decision node

The first decision consists of a choice between two options: (1) a screw-retained provisional prosthesis or (2) a cemented provisional prosthesis. The decision is based on the available space, the amount of bone resorption, and the possibility for placing implants at some distance from the embrasures of the denture teeth.

Second decision node

If the option “screw-retained prosthesis” is chosen in the first decision node, the clinician continues on the decision tree with another choice. After completion of osseointegration and maturation of the



▲ **Fig 13-2b** Treatment option for rehabilitation of the anterior mandible when a screw-retained provisional prosthesis is preferred. The sequence of steps is indicated in red. With this option, the final prosthesis can be either screw retained or cemented.

soft tissues, the clinician must determine if the final prosthesis should be screw retained or cemented.

If the option "cemented prosthesis" is selected for the provisional prosthesis, there is no other choice to be made; the final prosthesis will also be cemented.

The various treatment options for the edentulous anterior mandible are now considered.

Treatment options for rehabilitation of the edentulous anterior mandible (single crown or multi-unit prosthesis)

- Option 1:** Screw-retained provisional prosthesis placed within 72 hours after surgery; the prosthesis is fabricated entirely in the laboratory.
- Option 2:** Cemented provisional prosthesis placed within 72 hours after surgery; the prosthesis is fabricated entirely in the laboratory

Treatment option I

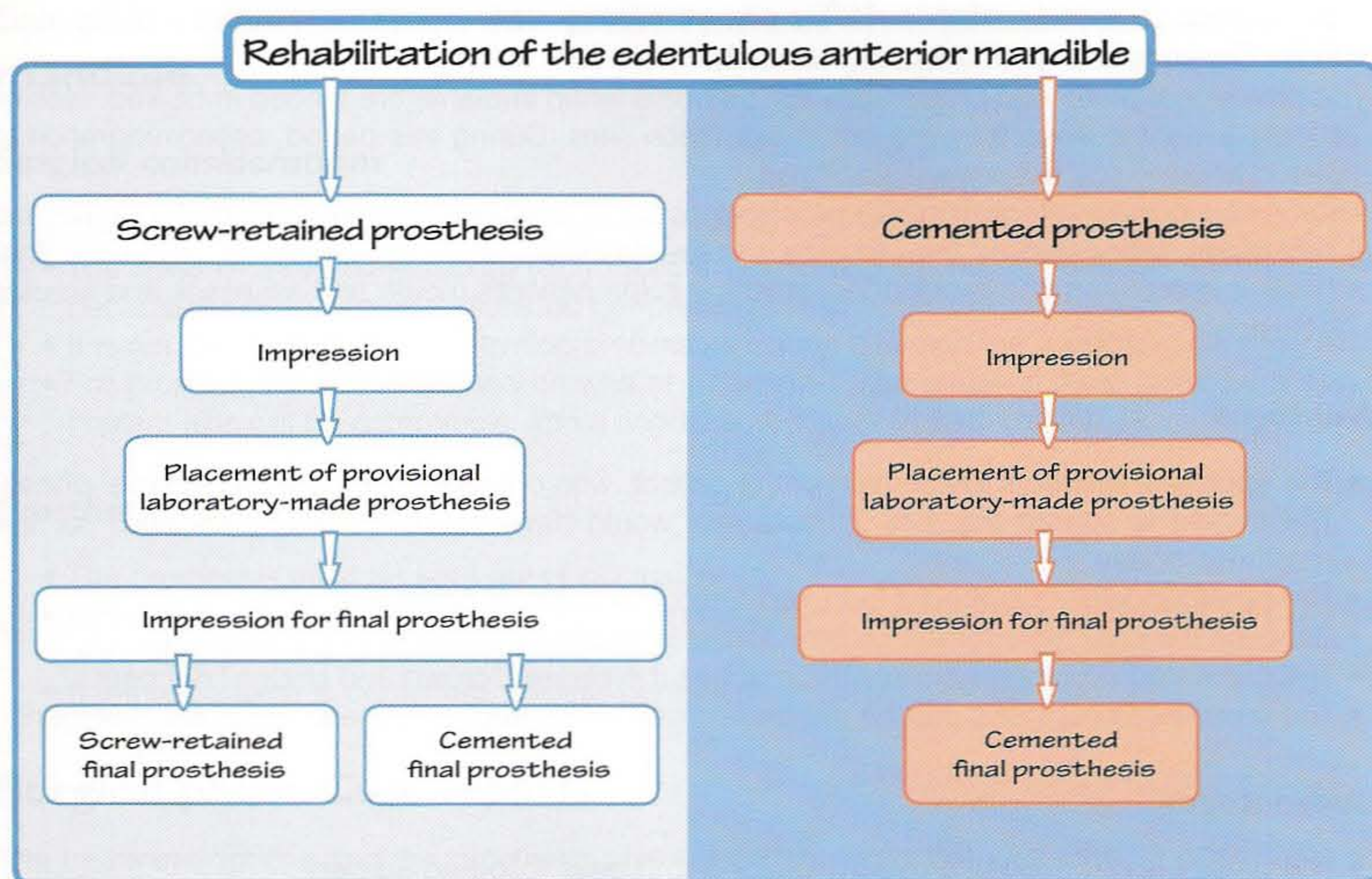
Screw-retained provisional prosthesis placed within 72 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

This option (Fig 13-2b) is chosen when:

- A screw-retained prosthesis is preferred to a cemented prosthesis.
- The implants' axes are compatible with lingual anterior screw access paths.

The laboratory makes the prosthesis in its entirety. The prosthodontist treats the patient in two distinct visits; the prosthesis is delivered within 72 hours after surgery.

After verifying osseointegration, the prosthodontist can proceed with fabrication of either a screw-retained or cemented final prosthesis, fabricated by the laboratory in the usual way from an



▲ **Fig 13-2c** Treatment option for rehabilitation of the anterior mandible when a cemented provisional prosthesis is preferred. The sequence of steps is indicated in red. With this option, the final prosthesis is usually cemented.

impression. When the prosthesis is completed, the prosthodontist tries it in the patient's mouth and assesses and adjusts the occlusion.

Advantages

- This approach respects the comfort of the patient, who only has to endure the surgical phase. The patient is spared the 1 to 2 hours that would have been needed in the chair for the prosthetic phase.
- The prosthodontist is spared a long and tedious session at chairside.
- The use of cement, which can irritate the soft tissue, is avoided.
- The clinician can easily unscrew the prosthesis to assess implant osseointegration.
- Because the chair time for the prosthodontist is reduced, the fee can be reduced.

Disadvantages

- The patient is deprived of a restoration for 1 to 3 days following surgery.
- If the wax bite registration is inaccurate, the prosthetic procedure may have to be repeated.
- The screw-retained prosthesis may loosen.

Treatment option 2

Cemented provisional prosthesis placed within 72 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

This option (Fig 13-2c) is chosen when:

- A cemented prosthesis is preferred to a screw-retained prosthesis.

The laboratory constructs the prosthesis in its entirety. The patient is treated in two distinct prosthetic sessions and is rehabilitated within 72 hours after surgery.

The provisional prosthetic phase lasts for 2 months when implants are placed in healed sites or for at least 3 months when they are put in extraction sites. During this period, osseointegration is completed and the soft tissues are stabilized.

After verifying osseointegration, the prosthodontist can proceed with fabrication of a cemented final prosthesis, fabricated by the laboratory in the usual way from an impression. After the final prosthesis is completed, the prosthodontist tries it in the patient's mouth and assesses and adjusts the occlusion.

Advantages

- The approach respects the comfort of the patient, who only has to endure the surgical phase. The patient is spared the 1 to 2 hours that would have been needed in the chair for the prosthetic phase.
- The prosthodontist is spared a long and tedious session at chairside.
- Because the chair time for the prosthodontist is reduced, the fee can be reduced.
- The cemented prosthesis closely approaches the classic "crown and bridge" concept.
- The cemented prosthesis can be used effectively when implant access paths are divergent.

Disadvantages

- The patient is deprived of a restoration for 1 to 3 days following surgery.
- If the wax bite registration is inaccurate, the prosthetic procedure may have to be repeated.
- Excess cement can be trapped in the gingiva.
- The prosthesis can debond.

▼ Step-by-Step Guidelines for Immediate-Loading Treatment of the Anterior Mandible

Indications

- Available bone height at implant site: ≥ 10 mm
- Available bone width at implant site: ≥ 5 mm
- Bone quality: dense or normal (type 1-3)
- Number of implants: 1 to 4
- Insertion torque of each implant ≥ 35 Ncm

Contraindications

- If implants demonstrate inadequate primary stability, the immediate-loading protocol must be discontinued.
- If the crowns cannot be kept out of occlusion in protrusive excursions, immediate loading should not be attempted.
- Patients who exhibit bruxism are not good candidates for immediate loading.

Specific considerations for treatment of the edentulous anterior mandible

Surgical considerations

- The use of narrow-diameter implants is frequently indicated.
- The rules of three-dimensional (3D) implant positioning do not have to be strictly followed because esthetic considerations do not prevail (see chapter 5).
- It is not always possible to develop embrasure space between the prosthetic crowns.
- For prospective screw-retained crowns or prostheses, the surgeon must make sure that the implant axis will be compatible with a lingual screw access path (option 1).

Prosthetic considerations

- The prosthesis must be kept out of occlusion.
- Embrasure spaces must be managed with care if implant placement does not fully coincide with the position of the crowns.
- If the restoration is cemented, excess cement must be scrupulously removed (option 2).

Surgical phase: Case reports

The treatment options and the prosthetic phase for the anterior mandible that is edentulous or is becoming edentulous are identical; only the surgical phase differs. For this reason, this chapter will present various surgical situations but only one case for each prosthetic option.

The immediate-loading protocol is particularly suitable for treatment of the anterior mandible. Patients usually want rapid treatment to reduce the provisional restoration period to a minimum, and clinicians can readily satisfy this desire.

Replacement of teeth in mandibular anterior extraction sites

A woman suffered from advanced periodontal disease that affected only the mandibular anterior teeth; other teeth were healthy. She was not psychologically prepared to endure any time without anterior teeth. In addition, she wanted to avoid wearing a removable appliance during the provisional restoration period.

Presurgical preparation

Clinical and radiographic examinations

- Determination of the smile line (Fig 13-3a)
- Assessment of the periodontal condition of the teeth to be extracted and examination for any possible focal point of infection (Figs 13-3b and 13-3c)
- Confirmation of the need for serial tooth extraction
- Determination of the available bone height and width

Study casts: Preparation of a surgical guide

The surgical guide defines the tooth envelope and the mesiodistal position of the implants. Often, the number of implants that can be fitted in that area will be fewer than the number of teeth to be restored.

Surgical phase

Extraction of teeth

It may be necessary for tartar to be removed from the teeth before they are extracted. Depending on the reason for removal of the teeth, traumatic injury or infection, antibiotic preventive therapy is prescribed 2 hours or 3 days before surgery, respectively.

In this case, advanced periodontal disease dictated extraction of all the mandibular anterior teeth (see Fig 13-3c); antibiotic therapy was started 3 days before surgery. Atraumatic extraction was performed to avoid damaging the cortical plates, especially the buccal plate (Fig 13-3d).

Placement of implants

Selection of implant design and implant number.

1. *Implant width and design.* Because the most salient characteristic of this indication is the limited amount of space offered for implant placement, smaller diameter implants are often chosen. They must achieve the greatest primary stability possible in order to be successfully immediately loaded. Conical implants achieve this stability better than standard implants.
2. *Number of implants.* In the present case, with only two implants, the rules of implant placement would have been respected. However, the immediate-loading protocol requires that stresses be kept to a minimum, and this is even more important for implants with a reduced diameter. In this region, esthetic requirements are minimal; therefore, it was decided to add a third implant to ensure mechanical stability, although this would complicate the creation of embrasures between the implants.
3. *Implant length.* The radiograph showed that there was enough bone to support 13- and 15-mm-long implants. The depth of the alveoli was limited, so that drilling 3 to 5 mm beyond the apex of the alveoli to achieve primary stability was possible.

Preparation of osseous sites. A direct, blind approach, without a flap is performed, using a graduated implant holder. In this patient, the gingival height from the crest measured about 3 mm.

Drilling sequence. The drilling sequence is carried out in the usual way without pretapping.

3D implant positioning.

1. *Mesiodistal axis.* The mesiodistal axis, perpendicular to the supported crown, is indicated by the surgical guide (Fig 13-3e).
2. *Buccolingual axis.* The envelope of the prosthesis defines the buccolingual axis; this axis is incorporated in the surgical guide. Depending on whether the restoration will be screw retained or cemented, this axis can be inclined lingually to ensure that the screw access paths emerge on the lingual surface of the denture teeth.
3. *Coronoapical axis.* The implants are positioned level with the crest or slightly subcrestally because there is no real esthetic requirement. Nevertheless, this positioning should facilitate preparation of a harmonious emergence profile for the implant-supported crowns.

For this patient, three 13- and 15-mm-long conical NT implants (Biomet 3i) with a diameter of 3.3 mm were inserted in the extraction sites (Figs 13-3f and 13-3g).

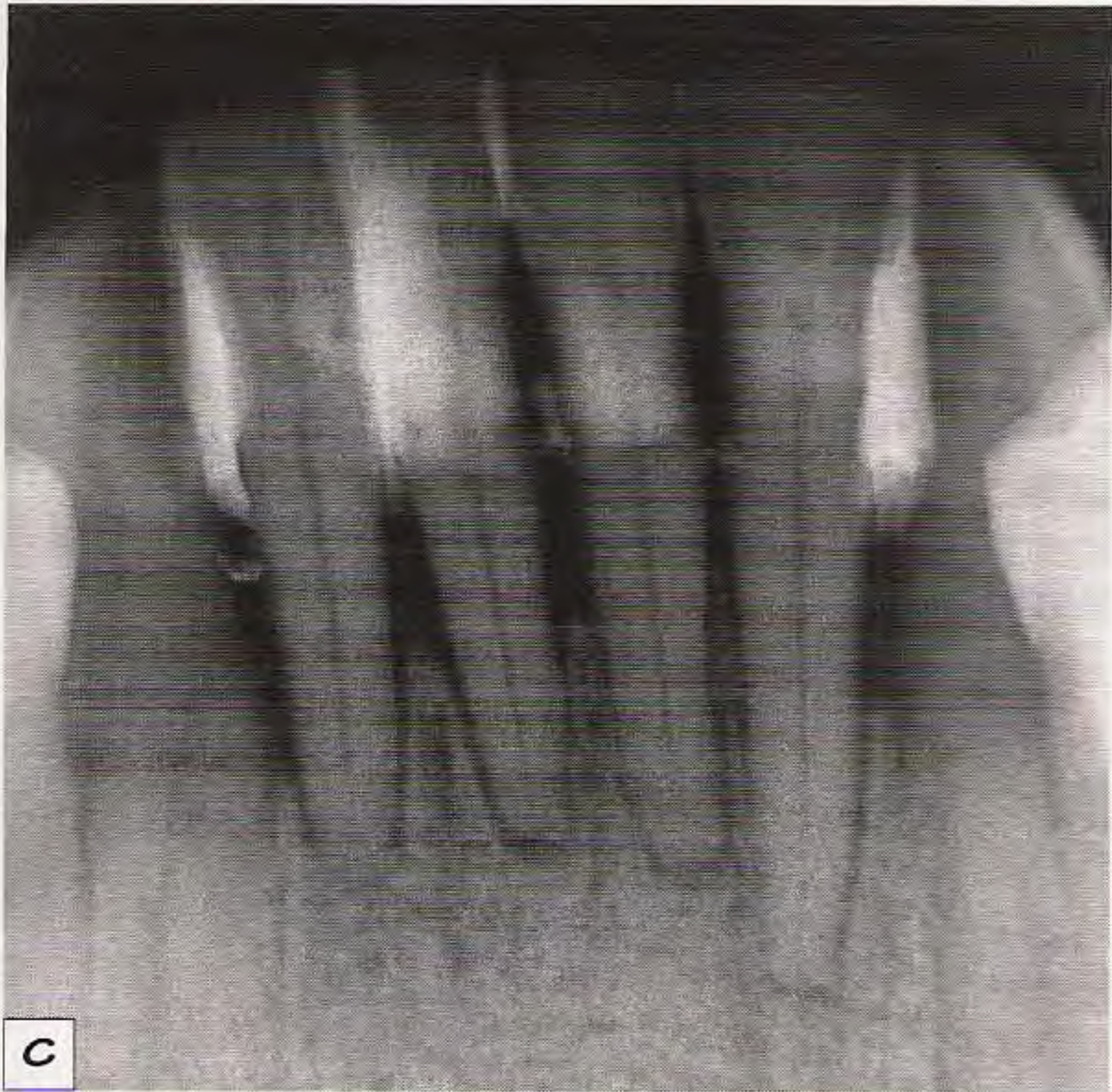
Primary stability. In this case, primary stability was achieved for every implant; insertion torque was greater than 35 Ncm.

Use of bone profiler. The bone profiler was not needed in this case. Because of the limited available space, the prosthetic abutments could not be larger than the neck of the implants.

Placement of healing abutments. The healing abutments were screwed in position to prevent the gingival tissue from collapsing (see Fig 13-3g); this marks the close of the surgical phase. The patient leaves the surgical treatment site and goes to the prosthetic treatment site.

Suturing. In this case, the fourth alveolus that did not receive an implant was sutured; the three implant sites were not.

Control radiograph. A radiograph was taken to verify that implant positioning is satisfactory (see Fig 13-3g).



▲ Fig 13-3 Clinical examination before surgery and implant placement. (a) Determination of the smile line. The lower lip hides the mandibular incisors completely. (b) Clinical evaluation of the remaining mandibular teeth. There is substantial gingival recession. (c) Periapical radiograph. Advanced periodontal disease with severe bone loss is confirmed. (d) Clinical view after extraction of the four incisors. The teeth are narrow and have left only a limited amount of mesiodistal space available for restoration. (e) Surgical guide. It reaffirms the most salient characteristic of this region, a restricted area for placement of implants. (f) Implants placed in the extraction sites. Placement is performed with a graduated implant holder; 3 mm below the gingival margin of the sites. (g) Control radiograph. Note the crestal placement and the close proximity of the two implants on the left.

Transition from surgical treatment site to prosthetic treatment site. The transition of the patient is carefully planned in advance to eliminate the possibility of misunderstandings and to ensure that the patient experiences a seamless transfer from one office to another.

The prosthetic phase will be discussed later in the chapter.

Replacement of teeth in mandibular anterior healed sites

A young adult who had lost three mandibular incisors in a traffic accident came for implant treatment with the hope of having them replaced as swiftly as possible (Fig 13-4a).

Presurgical preparation

Clinical examination

- Determination of the smile line
- Assessment of the available bone height and width
- Determination of the extent of ridge resorption (Figs 13-4a and 13-4b)

Radiographic examination

Usually, the height and width of the crest are precisely determined using computerized tomography (CT). In this case, a periapical radiograph was enough to assess the height of the available bone (Fig 13-4c). The clinical examination showed that the width of the ridge was satisfactory.

Study casts: Preparation of surgical guide

The surgical guide for this case was restrictive (Fig 13-4d). It defined the mesiodistal and buccolingual axes of the implants. As in many other cases of restoration of lost mandibular anterior teeth, the number of implants was inferior to the number of teeth being restored.

Surgical phase

Placement of implants

Selection of implant design and number.

1. *Implant width and design.* The most salient characteristic of the area is the limited amount of space it offers for the placement of implants; narrow-body implants are therefore more appropriate. They must achieve the firmest primary stability possible to achieve success with the immediate-loading protocol. Conical implants or flared-neck implants are most suitable because they accomplish this requirement better than standard implants.
2. *Number of implants.* In this case, sufficient support of the immediately loaded prosthesis could be obtained with only two narrow implants with a wide neck, because the bone quality was satisfactory and the wide neck would increase primary stability. A third implant was not needed; this allowed the surgeon to maintain an adequate distance between the implants and between the implants and adjacent teeth.
3. *Implant length.* There was enough available bone to support 13-mm-long implants (see Fig 13-4c).

Preparation of osseous sites. A flap is raised without a releasing incision; the marginal incision passes through the sulci of the adjacent teeth.

Drilling sequence. The site is prepared in the usual way without tapping.

3D implant placement.

1. *Mesiodistal axis.* The mesiodistal axis was parallel to the crown of the restoration supported by the implant, as indicated by the surgical guide (Figs 13-4d and 13-4e).
2. *Buccolingual axis.* The buccolingual axis is controlled by the envelope of the prosthesis, as indicated by the surgical guide. If the restoration is to be screw retained, this axis may be tilted lingually to ensure that the screw access paths will emerge on the lingual surface of the restored crowns.

3. *Coronoapical axis.* There are virtually no esthetic considerations in the mandibular anterior region; therefore implant placement does not need to strictly follow the rules of 3D positioning. The implant can be placed level with the crest or slightly subcrestally, depending on which position will aid development of a harmonious emergence profile.

Two Osseotite Prevail implants with diameters of 3.4 and 3.8 mm at the neck were placed; they were 13.0 and 15.0 mm long, respectively (Figs 13-4f and 13-4g).

Primary stability. The primary stability was satisfactory in this case, with insertion torque of greater than 35 Ncm for each implant.

Placement of healing abutments and suturing. The healing abutments are screwed in the necks of the implants, and the edges of the incision are sutured around them (Fig 13-4h). This step marks the close of the surgical phase, and the patient proceeds from the surgical office to the office of the prosthodontist.

Control radiograph. A radiograph is taken to verify that the implant position is satisfactory (Fig 13-4i).

Transition from surgical site to prosthetic site. The transition is carefully planned in advance to eliminate the possibility of misunderstandings and to ensure that the patient experiences a seamless transfer from one office to the other.

Prosthetic phase: Treatment option 1

Screw-retained provisional prosthesis placed within 72 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

Reminder:

This option is chosen when a screw-retained prosthesis is preferred. The patient is treated in two visits of reasonable duration, 1 day apart.

Key information for treatment option 1

Figure 13-5 summarizes the key aspects of the prosthetic treatment for option 1.

Technical difficulty is low

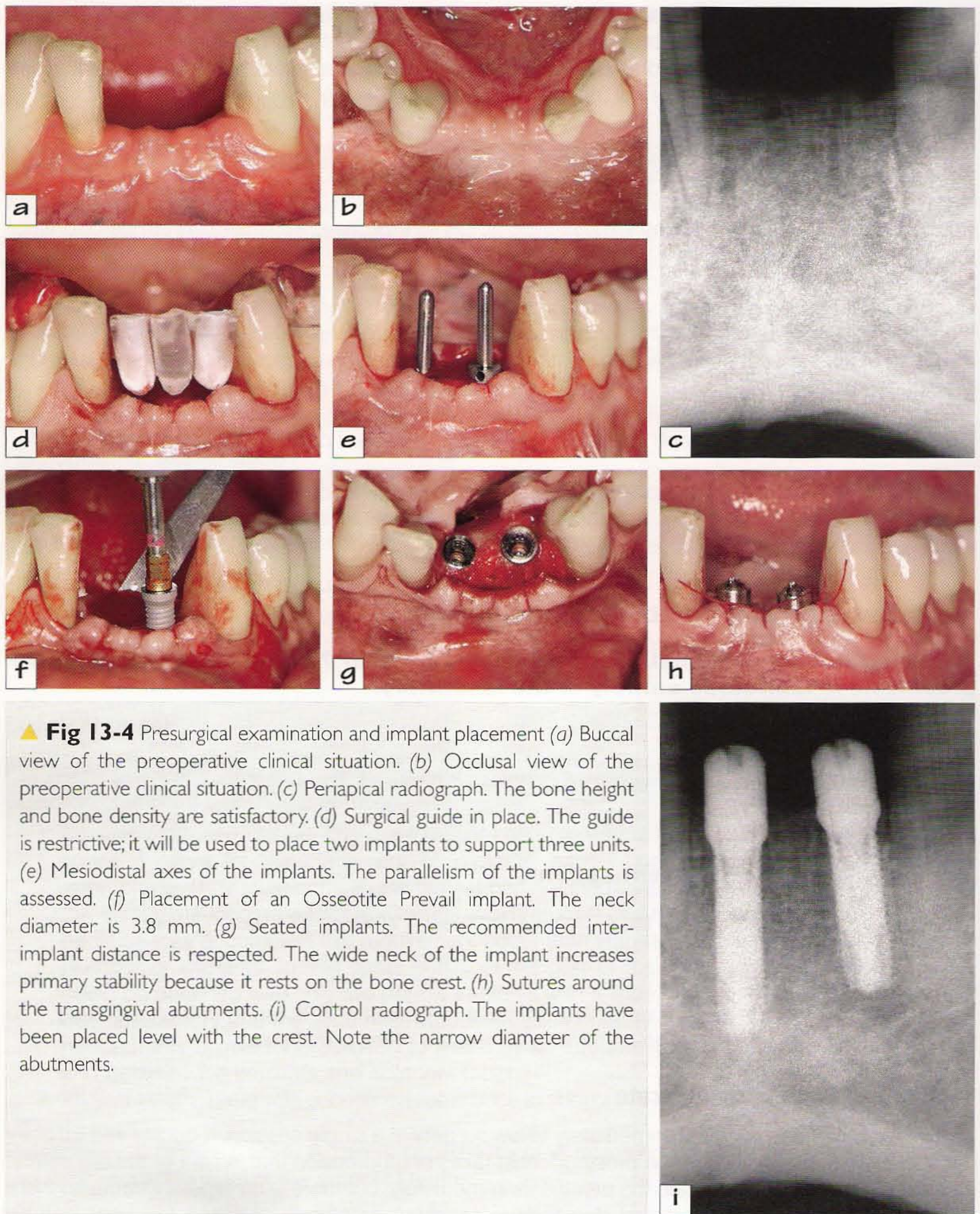
The prosthetic phase is greatly simplified because the prosthesis is made in the laboratory. The screw access holes must emerge on the lingual surface of the prosthesis.

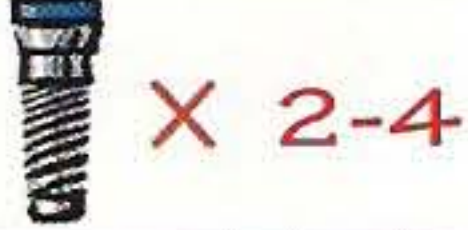
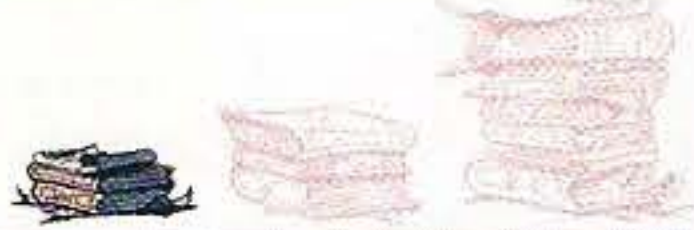
Team coordination is moderate

The prosthetic phase does not immediately follow surgery in a single session. It begins immediately after implant placement when the prosthodontist takes an impression that is sent to the laboratory. The laboratory starts to fabricate the prosthesis immediately, but there is no urgency because there are no critical esthetic or functional demands to satisfy. A prosthesis of only a few units can be easily fabricated within 72 hours.

Treatment time is limited

The surgical and prosthetic phases are not immediately consecutive. They are carried out in stages of 1 to 1.5 hours for the surgical phase, depending on how many implants are placed, and 1 to 1.5 hours for the prosthetic phase, which is divided into two sessions. In the first session the impression is made and in the second the prosthesis is placed.



Technical difficulty		Esthetic requirements	
Team coordination		Extra costs	
Treatment time		Risk assessment	
Number of implants		Documentation	

▲ **Fig 13-5** Key information for treatment option 1.

Number of implants: 2 to 4

The number of implants varies, depending on the number of missing teeth and the available space.

Esthetic requirements are low or nonexistent

Esthetic considerations are usually nonexistent for this indication. The rules for 3D implant positioning do not need to be strictly followed.

Extra costs are moderate

The provisional prosthetic phase consists of fabrication of a fixed prosthesis, which entails a certain cost. However, the prosthodontist's chair time is limited, thus reducing the patient's fee.

Additional risk is low

Obtaining good primary stability should not pose a special problem in this region. The ability to keep the prosthesis out of occlusion is one of the inclusion criteria; therefore the stresses applied to the implants are minor.

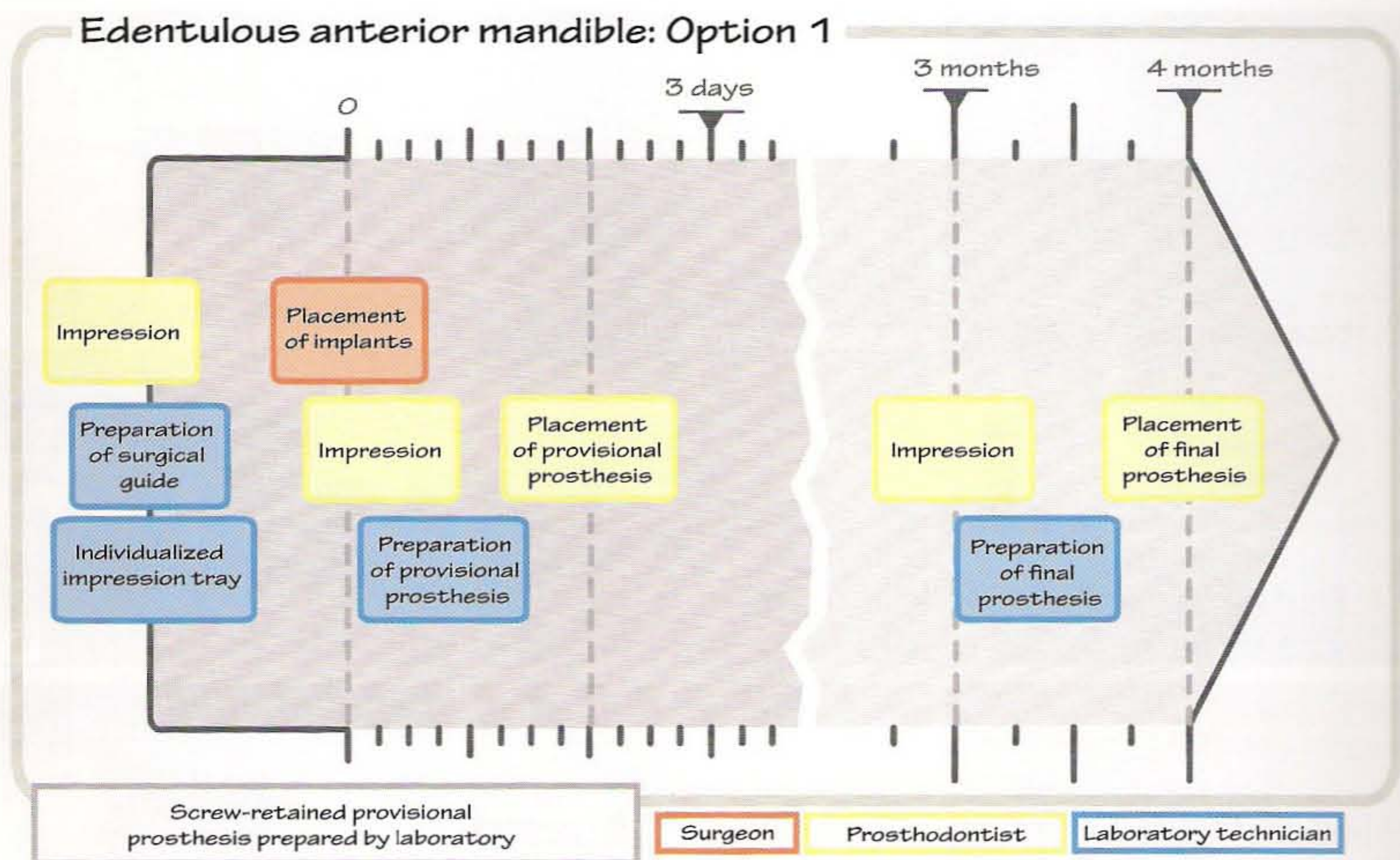
Documentation in the literature is scarce

The only reports published so far about immediate loading in this region have been anecdotal.

Sequence and timing of steps for treatment option 1

Figure 13-6 illustrates the chronology of the treatment carried out according to option 1:

- The laboratory proceeds in two stages. Before implant placement, the laboratory makes the surgical guide and the individualized impression tray. Afterward, the laboratory constructs the prosthesis.
- The implants are placed in the usual way.
- The prosthodontist takes an impression immediately after the surgical procedure.
- The provisional prosthetic phase is completed within 72 hours in another visit, when the prosthodontist affixes the provisional prosthesis.
- After 2 to 3 months of function, the implant stability is checked. If the stability is satisfactory, fabrication of the final prosthesis can begin.
- The final prosthetic phase continues in the usual manner



▲ Fig 13-6 Sequence and timing of steps for treatment option 1. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Checklist of materials required for treatment option 1

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Individualized impression tray

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutment or transgingival immediate occlusal loading (IOL) abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Materials needed for a pick-up impression, including the appropriate number of impression copings (prosthodontist)

If provisional cylinders are used

- Implant analogs (laboratory)
- Provisional cylinders (laboratory)
- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)

If provisional abutments are used

- Abutment analogs (laboratory)
- IOL cylinders (laboratory)

- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

These stages described in the previous section are the same for all options. The following case illustrates application of option 1 for the prosthetic phase.

Case history

An elderly woman suffering from respiratory insufficiency asked for restoration of her anterior mandible (Fig 13-7a). The radiographic examination revealed advanced periodontal disease (Fig 13-7b). In view of her poor health, the treatment had to be carried out within fewer visits of shorter duration.

The five remaining anterior teeth were extracted. The globular canines left large alveoli (Fig 13-7c). Four implants were placed, three of them in extraction sites. The alveolus of the left canine had suffered so much bone loss that it was incapable of receiving an implant. The most distal implant on that side was in the lateral incisor site. To achieve good primary stability, two implants were placed 2 to 3 mm subcrestally; the other two were positioned level with the crest. Transgingival IOL abutments, 2 to 4 mm in height, were used to compensate for these variations in depth. With the placement of healing caps, the surgical phase came to a conclusion (Fig 13-7d).

Provisional prosthetic phase

Impression

For the impression procedures, the healing caps are replaced with impression copings screwed in the abutments (Fig 13-8a). No control radiograph is needed because of the internal connection. The individualized impression tray is tried in the mouth to eliminate all contacts with the impression copings (Fig 13-8b). An adhesive film is painted over the tray to bind the impression material to the tray (Fig 13-8c). A piece of surgical tape is placed over the prepared impression tray to prevent diffusion of the impression material (Fig 13-8d). The impression material is added to the tray (Fig 13-8e) and placed over the copings (Fig 13-8f). The tray is held in place with finger pressure over the adhesive tape (Fig 13-8g); this enables the prosthodontist to detect the position of the screw heads of the copings. When the tape is removed, the screw heads are immediately visible (Fig 13-8h).

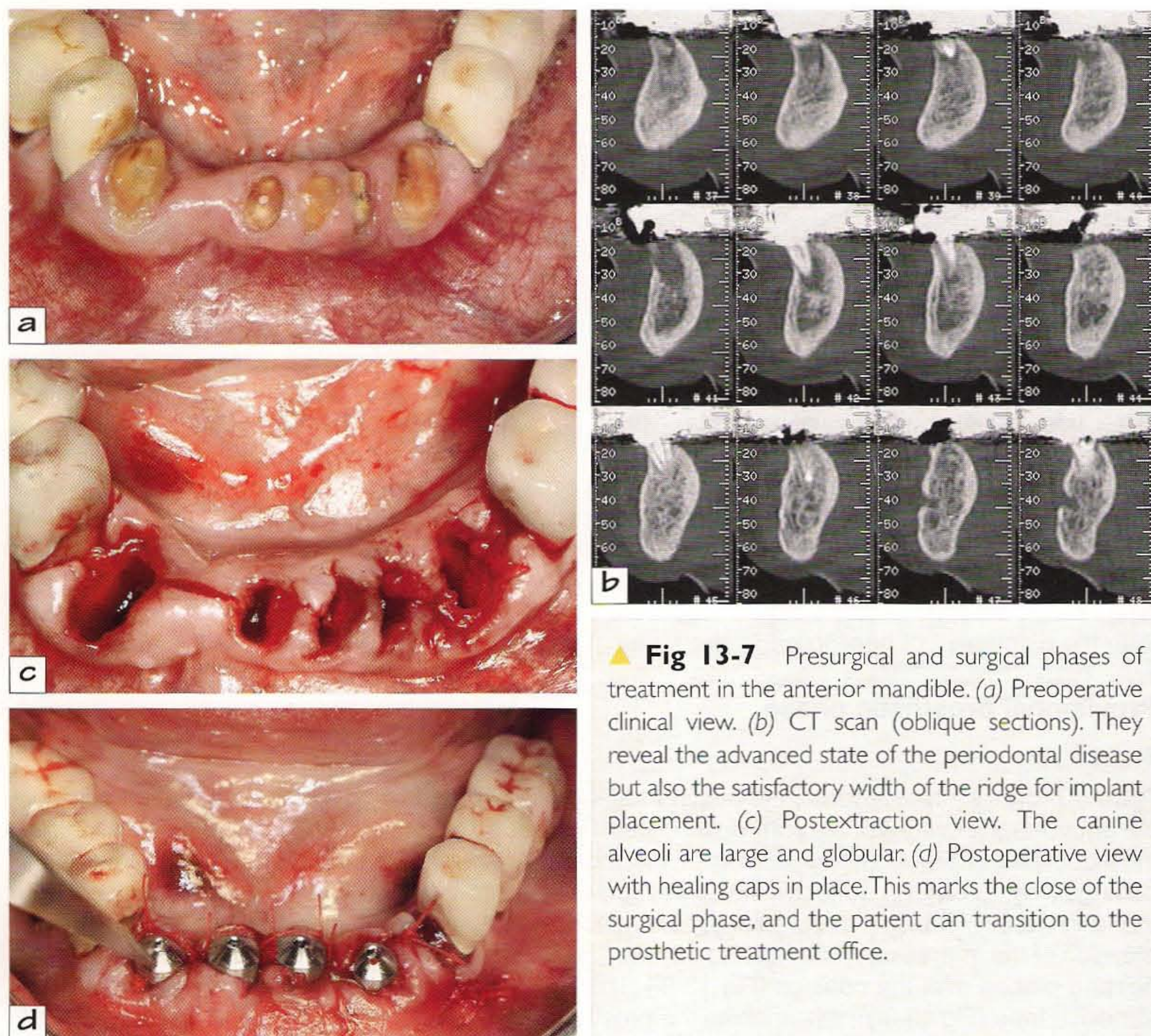
Figure 13-8i shows the impression with the impression copings of the IOL abutments. The interocclusal relationship is registered (Fig 13-8j) and sent with the impression to the laboratory to be poured with abutment analogs.

Laboratory procedures

The laboratory pours the casts with abutments analogs in place. The prosthesis is mounted on provisional IOL cylinders in the same way as a complete-arch prosthesis. The prosthesis for this patient incorporated a small distal extension (Fig 13-9a).

Delivery of prosthesis at chairside

After 48 hours, the prosthodontist places the prosthesis directly on the abutments. In this case, the screw access holes were not on the lingual surface of the restored teeth (Fig 13-9b). The prosthesis was adjusted to bring it out of occlusion. Because of the local bone situation, implants had to intrude on the space reserved for the embrasures on the prosthesis (see Fig 13-9a); nevertheless the esthetic result was acceptable (Fig 13-9c).



▲ **Fig 13-7** Presurgical and surgical phases of treatment in the anterior mandible. (a) Preoperative clinical view. (b) CT scan (oblique sections). They reveal the advanced state of the periodontal disease but also the satisfactory width of the ridge for implant placement. (c) Postextraction view. The canine alveoli are large and globular. (d) Postoperative view with healing caps in place. This marks the close of the surgical phase, and the patient can transition to the prosthetic treatment office.

Prosthetic phase: Treatment option 2

Cemented provisional prosthesis placed within 72 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

Reminder:

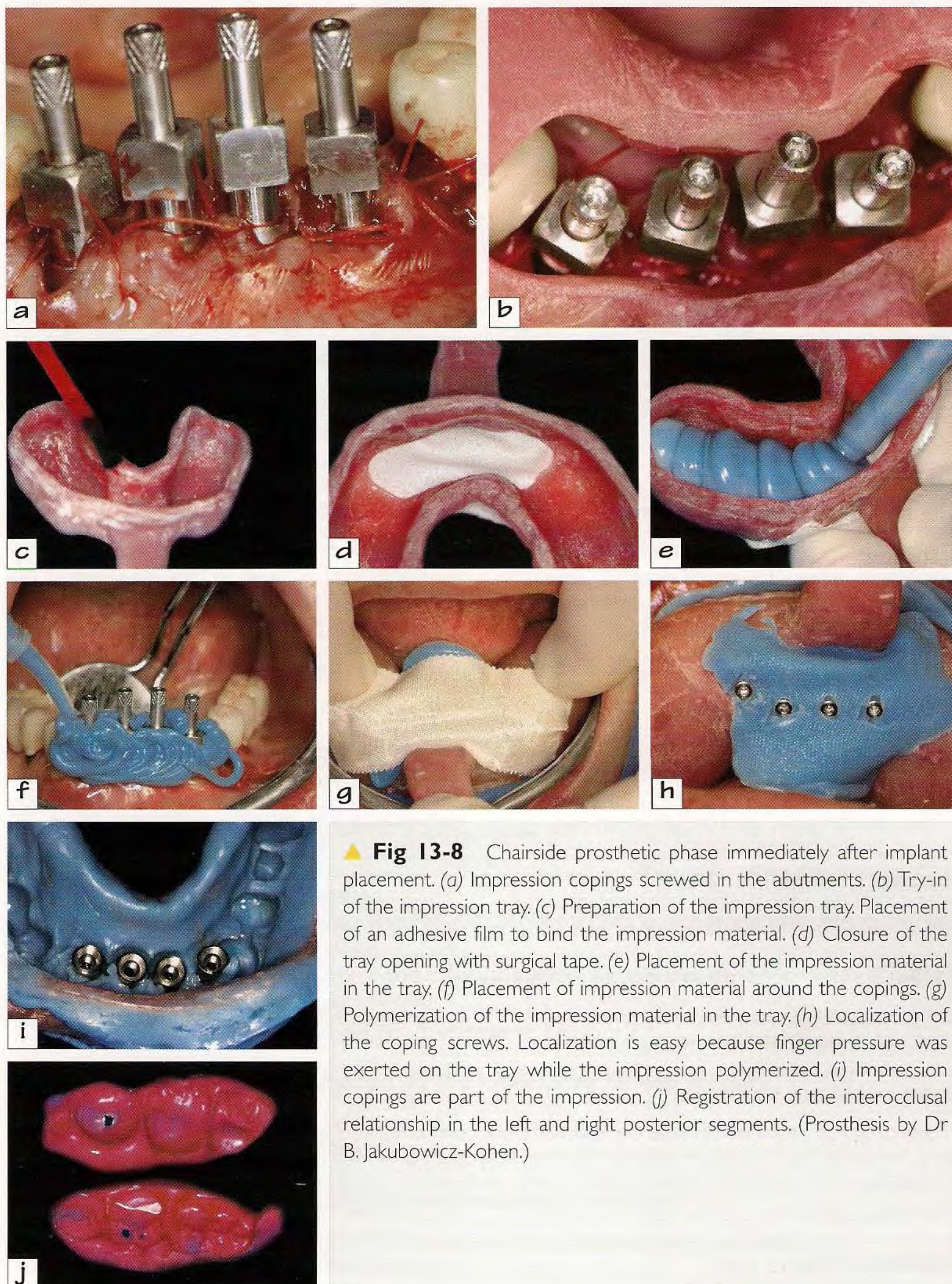
This option is chosen when a cemented prosthesis is preferred. The patient is treated in two visits of reasonable duration, 1 day apart.

Key information for treatment option 2

Figure 13-10 summarizes the key aspects of prosthetic treatment according to option 2.

Technical difficulty is low

The prosthetic phase is greatly simplified because the prosthesis is made in the laboratory. The screw access holes must emerge on the lingual surface of the prosthesis.





▲ **Fig 13-9** Placement of the provisional prosthesis in the mouth 48 hours after surgery. (a) Prosthesis before placement in the mouth. Note the location of the implants at the embrasures of the denture teeth. (b) Occlusal view of the prosthesis in the mouth. The prosthesis has been taken out of occlusion. (c) Buccal view of the prosthesis in the mouth. Esthetics is satisfactory, even though the implants are located behind the embrasures of the denture teeth. (Prosthesis by Dr B. Jakubowicz-Kohen.)

Team coordination is moderate

The prosthetic phase does not follow surgery in a single session. It begins immediately after implant placement when the prosthodontist takes an impression that is sent to the laboratory. The laboratory starts to fabricate the prosthesis immediately, but there is no urgency because there are no critical esthetic or functional demands to satisfy. A prosthesis of only a few units can be easily fabricated within 72 hours.

Treatment time is limited

The surgical and the prosthetic phases are not immediately consecutive. They are carried out in stages of 1 to 1.5 hours for the surgical phase, depending on how many implants are placed, and 1 to 1.5 hours for the prosthetic phase, which is divided into two sessions. In the first session, the impression is taken, and in the second the prosthesis is placed.

Number of implants: 2 to 4

The implant number varies depending on the number of missing teeth and the space available.

Esthetic requirements are low or nonexistent

Esthetic requirements are usually nonexistent for this indication. The rules for implant positioning do not need to be strictly followed.

Extra costs are moderate

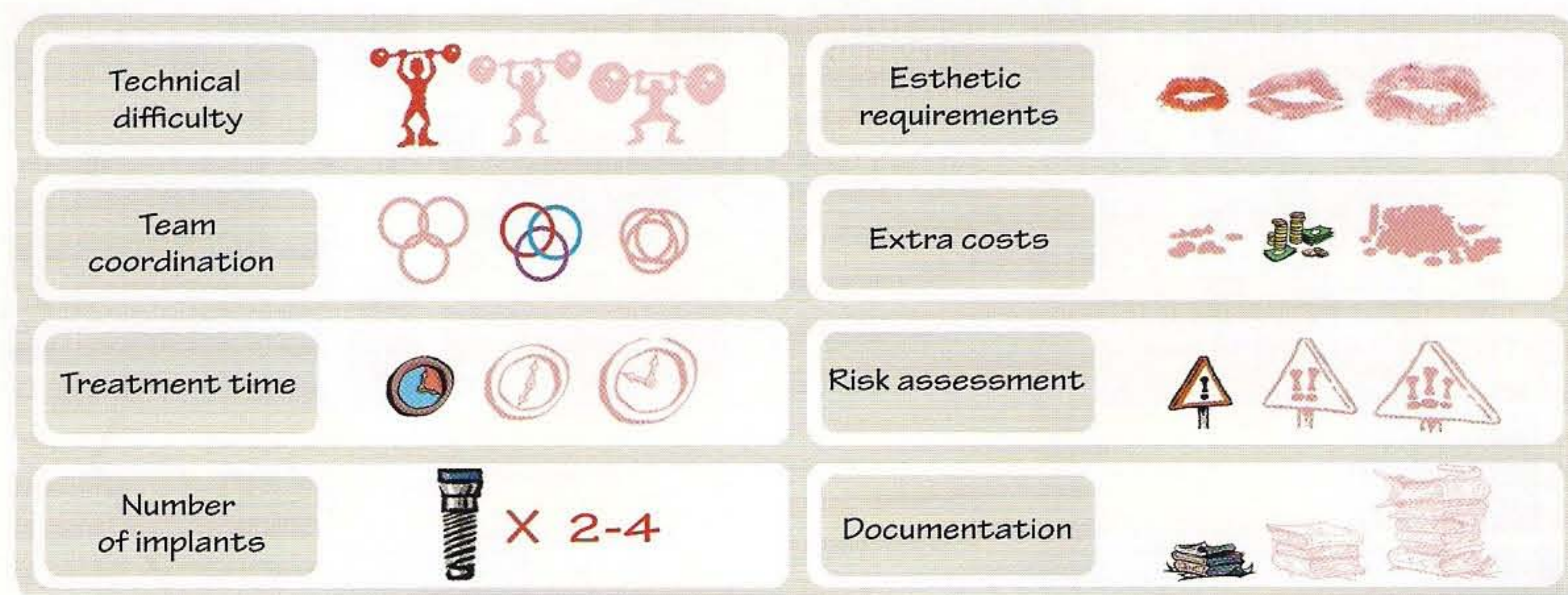
The provisional prosthetic phase consists of fabrication of a fixed prosthesis, which entails a certain cost. However, the prosthodontist's chair time is limited, and thus the patient's fee can be reduced. Supplementary costs are even lower if the provisional abutments can be used for the final prosthesis.

Additional risk is low

Obtaining good primary stability should not pose a special problem in this region. Keeping the prosthesis out of occlusion is one of the inclusion criteria; therefore, the stresses exerted on the implants are minor.

Documentation in the literature is scarce

The only reports published so far about immediate loading in this region have been anecdotal.



▲ **Fig 13-10** Key information for treatment option 2.

Sequence and timing of steps for treatment option 2

Figure 13-11 illustrates the chronology for treatment option 2:

- The laboratory proceeds in two stages. Before implant placement, the laboratory makes the surgical guide and the individualized impression tray. Afterward, the laboratory constructs the prosthesis.
- The implants are placed in the usual way.
- The prosthodontist takes an impression immediately after the surgical procedure.
- The prosthetic phase is completed within 72 hours in another visit, when the prosthodontist affixes the provisional prosthesis.
- After 2 to 3 months of function, the implant stability is checked. If it is satisfactory, fabrication of the final prosthesis can start.
- The final prosthetic phase continues in the usual manner

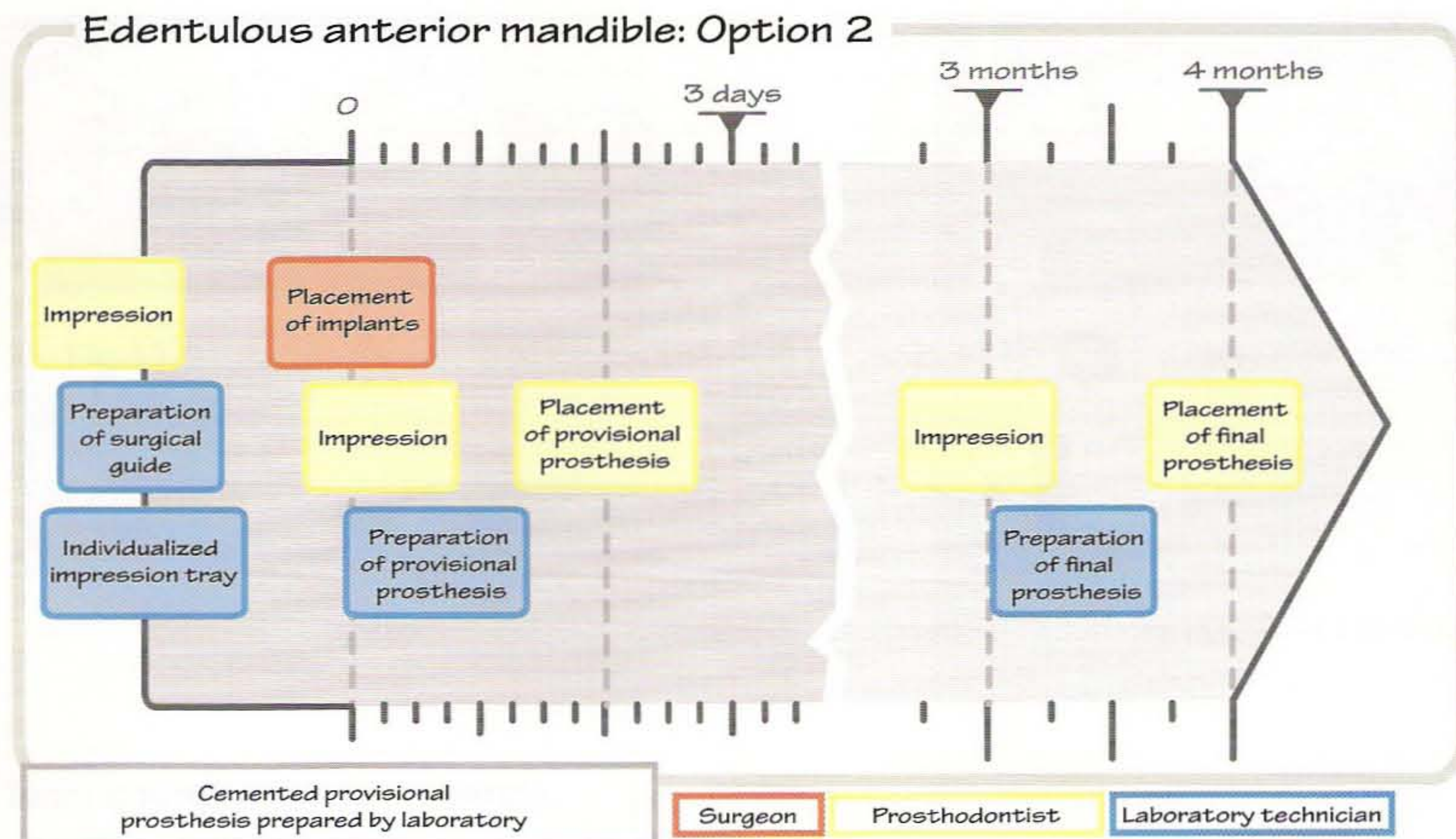
Checklist of materials required for treatment option 2

Prosthetic components prepared by the laboratory before surgery

- Surgical guide
- Individualized impression tray

Materials required for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Materials needed for a pick-up impression, including the appropriate number of impression copings (prosthodontist)
- Implant analogs (laboratory)
- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)



▲ **Fig 13-11** Sequence and timing of steps for treatment option 2. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Immediate-loading protocol

Presurgical and surgical phases

These stages were described earlier in the chapter. They are the same for all prosthetic options. The following case illustrates application of option 2 during the prosthetic phase.

Case history

A patient had a conventional fixed prosthesis that was failing because of advanced periodontal disease affecting her mandibular anterior teeth (Fig 13-12a). She wanted rapid treatment to avoid any protracted period of speech difficulties.

The surgeon extracted the involved teeth and placed four conical NT implants in the extraction sites. The surgical intervention was concluded with the insertion of healing abutments and suturing of the flap (Fig 13-12b).

Provisional prosthetic phase

The patient arrives at the prosthetic office with the healing abutments in position (Figs 13-12b and 12-12c).

Impression

The healing abutments are unscrewed and replaced with impression copings screwed in the implant necks (Fig 13-13a). Because of the external connection of the implants, a control radiograph is taken. The individualized impression tray is tried in the mouth and an adhesive tape is placed over the tray to prevent extrusion of the impression material (Fig 13-13b). The heads of the screws are located as the impression material polymerizes.



▲ **Fig 13-12** Presurgical and surgical phases. (a) Preoperative periapical radiograph of the mandibular anterior teeth. Periodontal involvement necessitates extraction. (b) Postoperative clinical view. (c) Postoperative radiograph. The posterior segments of the mandible have already been restored with implant-supported prostheses. (Prosthesis by Dr M. Achour.)

The impression with the impression copings (Fig 13-13c) is sent to the laboratory with a wax bite of the interocclusal relationship.

Laboratory procedures

The laboratory pours the casts with implant analogs in place and prepares the titanium abutments that will support the provisional prosthesis (Fig 13-13d). Trying the prosthesis on the cast revealed that, in this case, the implants were located at the embrasures of the artificial teeth (Fig 13-13e).

Delivery of prosthesis at chairside

After 72 hours, the patient arrives at the prosthodontist's office with the healing abutments in place (Fig 13-14a). They are removed and replaced with titanium abutments (Fig 13-14b). The provisional prosthesis is cemented over the abutments (Figs 13-14c and 13-14d). After meticulously removing all excess cement, the prosthodontist takes the prosthesis out of occlusion (Fig 13-14e).

For this patient, the esthetics achieved was acceptable, despite the presence of the implants in the embrasure spaces of the denture teeth (Figs 13-14c and 13-14f).

Control radiograph

The control radiograph is taken as usual; in the present case, the metal reinforcement bar was visible (Fig 13-14g).

Follow-up

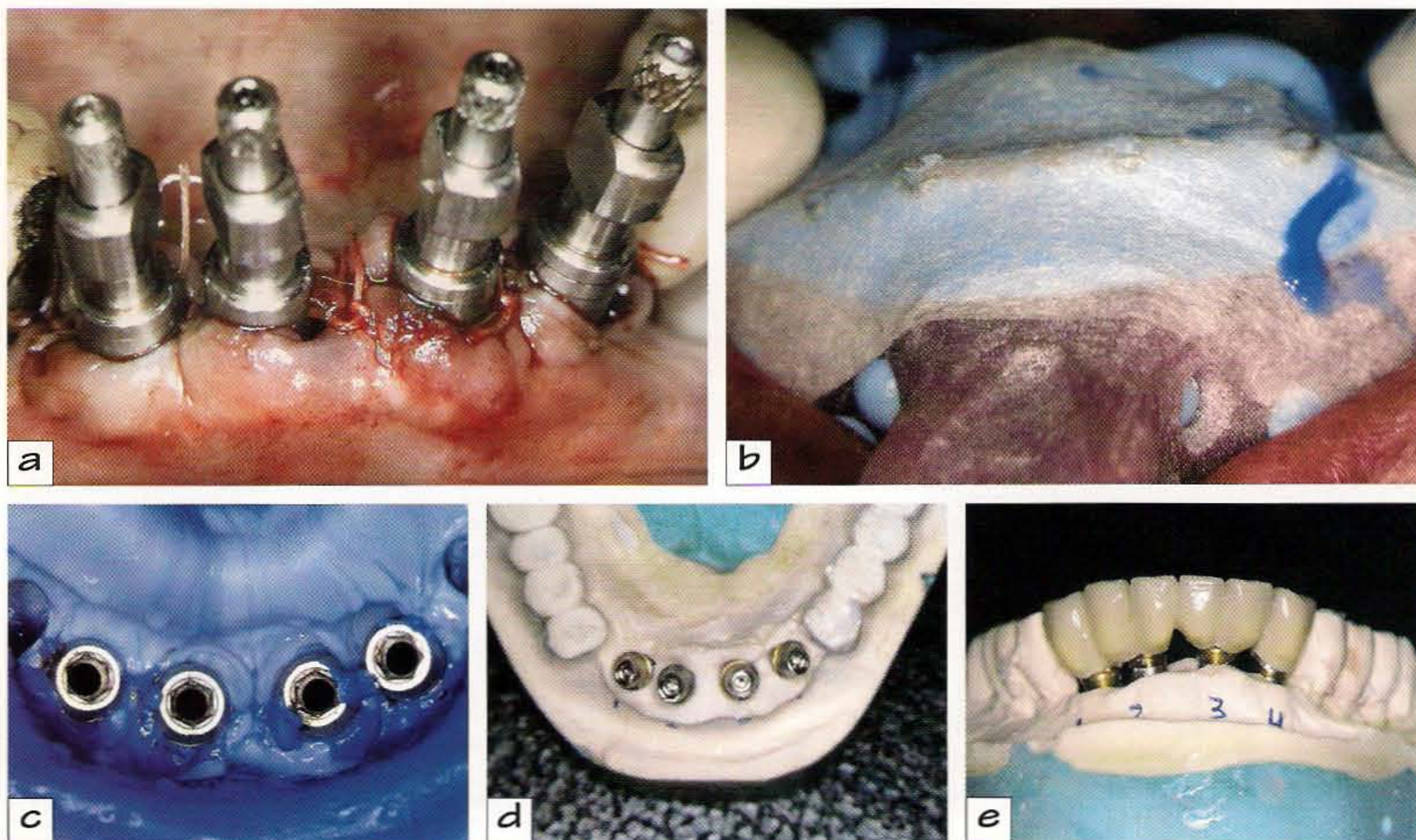
Final prosthesis

The final mandibular anterior prosthesis for this patient was placed 3 months after surgery. The laboratory technician constructed it so that the implants located in the embrasures of the artificial teeth were only minimally visible (Fig 13-15a). At the 1-year recall examination, the status of the soft and hard tissues was satisfactory (Fig 13-15b).

Control visits

Patients are advised to eat soft foods for the first 6 to 8 weeks after the placement of the prosthesis. Patients receive follow up examinations:

- After 1 day to evaluate the occlusion and assess the beginning of healing.
- After 10 days to assess soft tissue healing and to remove sutures.



▲ **Fig 13-13** Prosthetic phase carried out at chairside and by the laboratory. (a) Impression copings screwed in the implants. (b) Polymerization of the impression. The material had been prevented from diffusion by a piece of surgical tape, through which the prosthodontist can palpate the heads of the coping screws. (c) Impression with the impression copings in place. (d) Abutments prepared by the laboratory on the cast. (e) Trying the provisional prosthesis on the cast. (Prosthesis by Dr M. Achour.)

- After 1 month to assess the quality of soft tissue healing and to ensure that the patient is asymptomatic. It is not necessary to check implant stability either manually or with a stability testing device such as the Periotest (Medizintechnik Gulden) or Osstell (Osstell). If there is a specific reason for doing so, the screw-retained prosthesis can be removed. This action does not interfere with bone repair, but it is by no means routinely indicated. However, unseating of a cemented prosthesis is definitely contraindicated because this action could exert forces that would interfere with bone repair.
- At 2 to 3 months, depending on whether the implants were placed in healed or extraction sites, to assess osseointegration. This assessment is described in detail in the section on the final prosthetic phase.

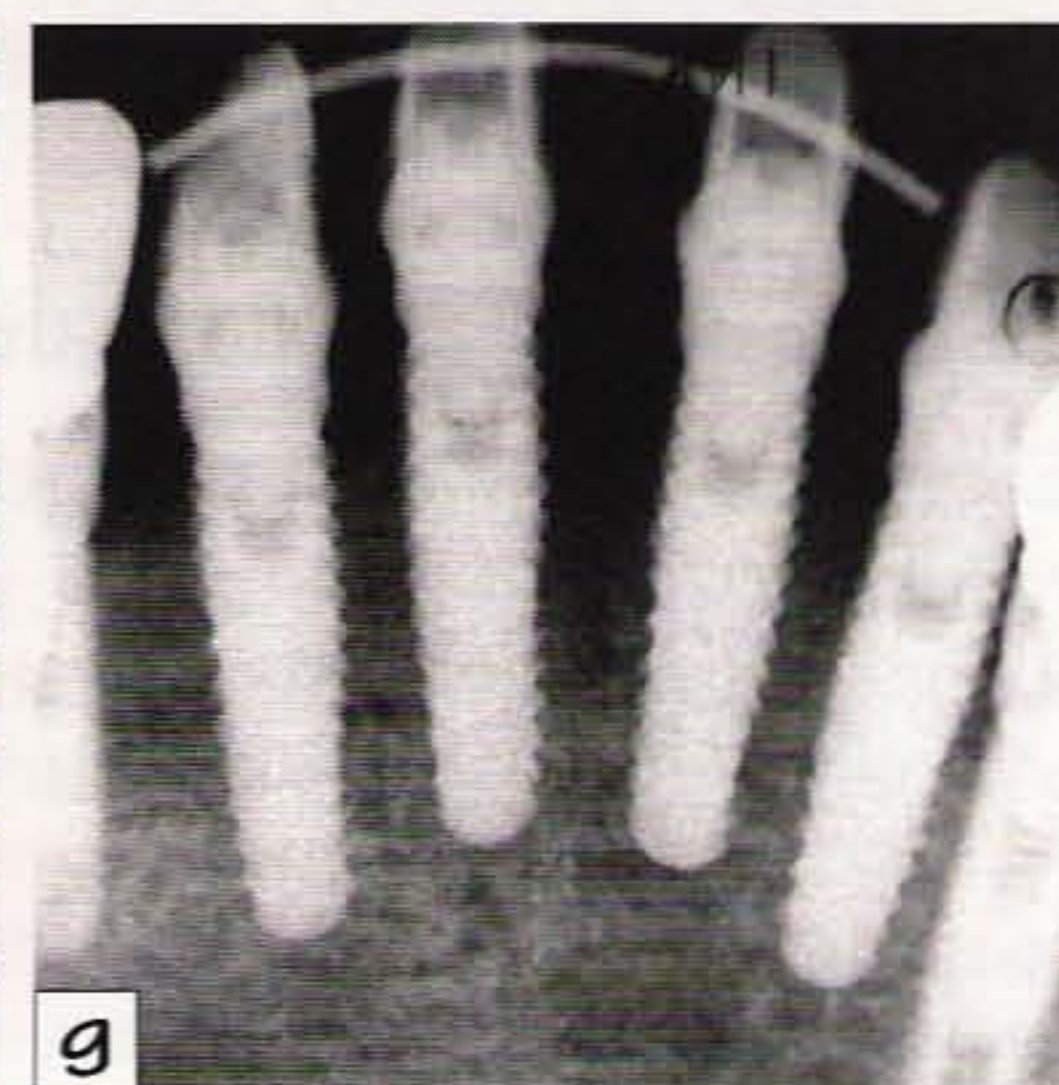
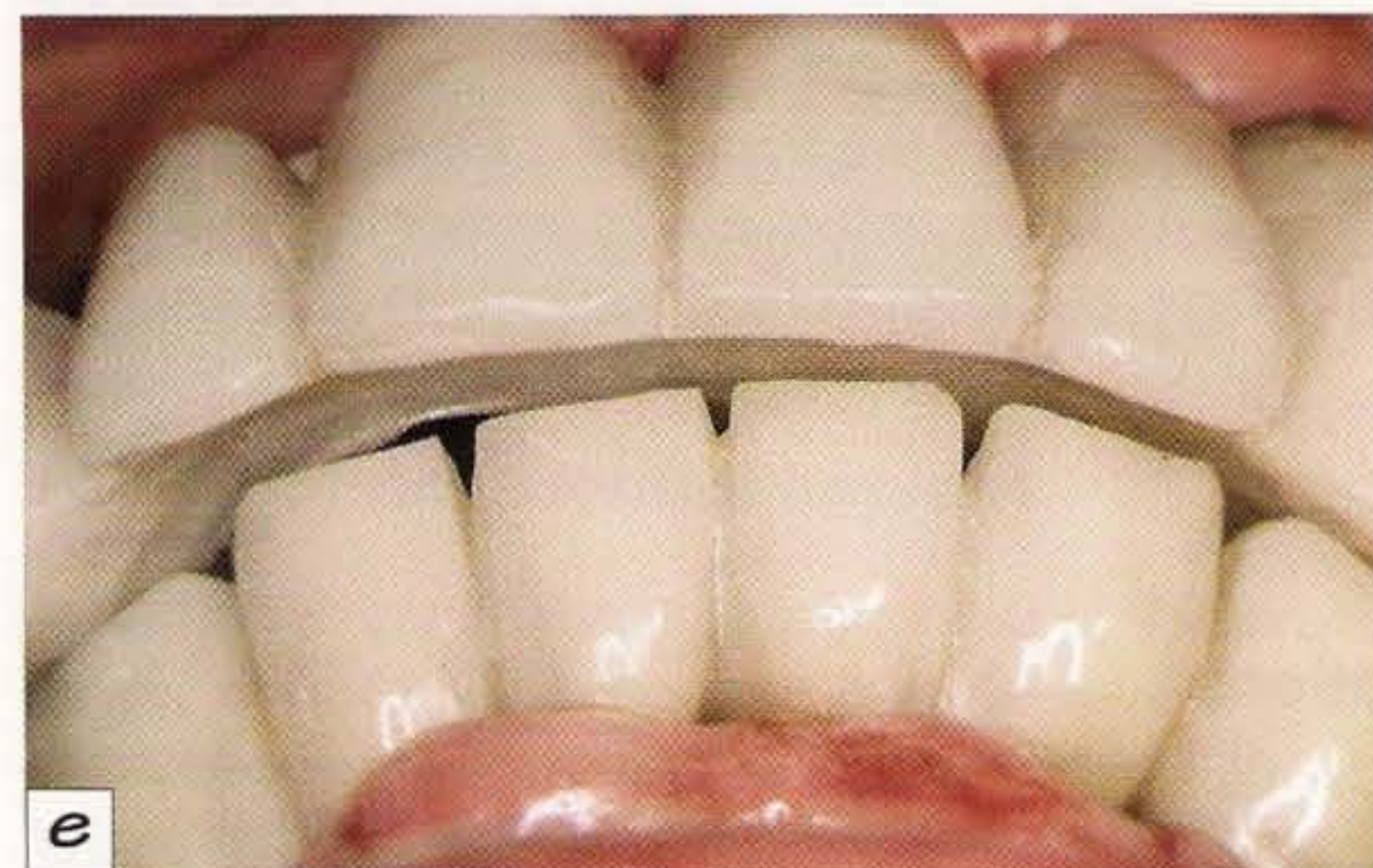
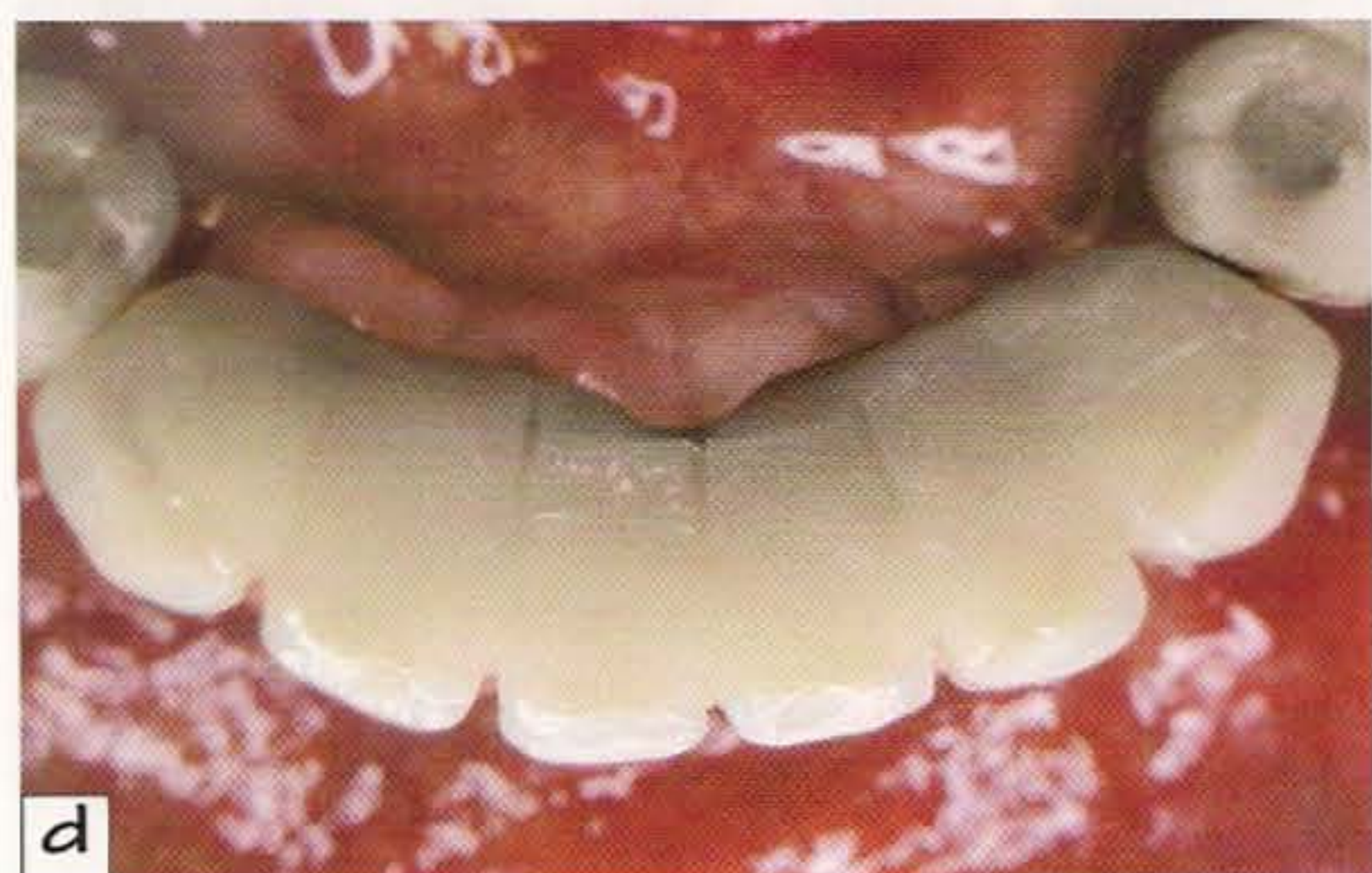
Management of complications

Complications can occur during the surgical phase, the prosthetic phase, or after delivery of the provisional or the final prosthesis. These complications may be common to all options or specific to a given prosthetic option.

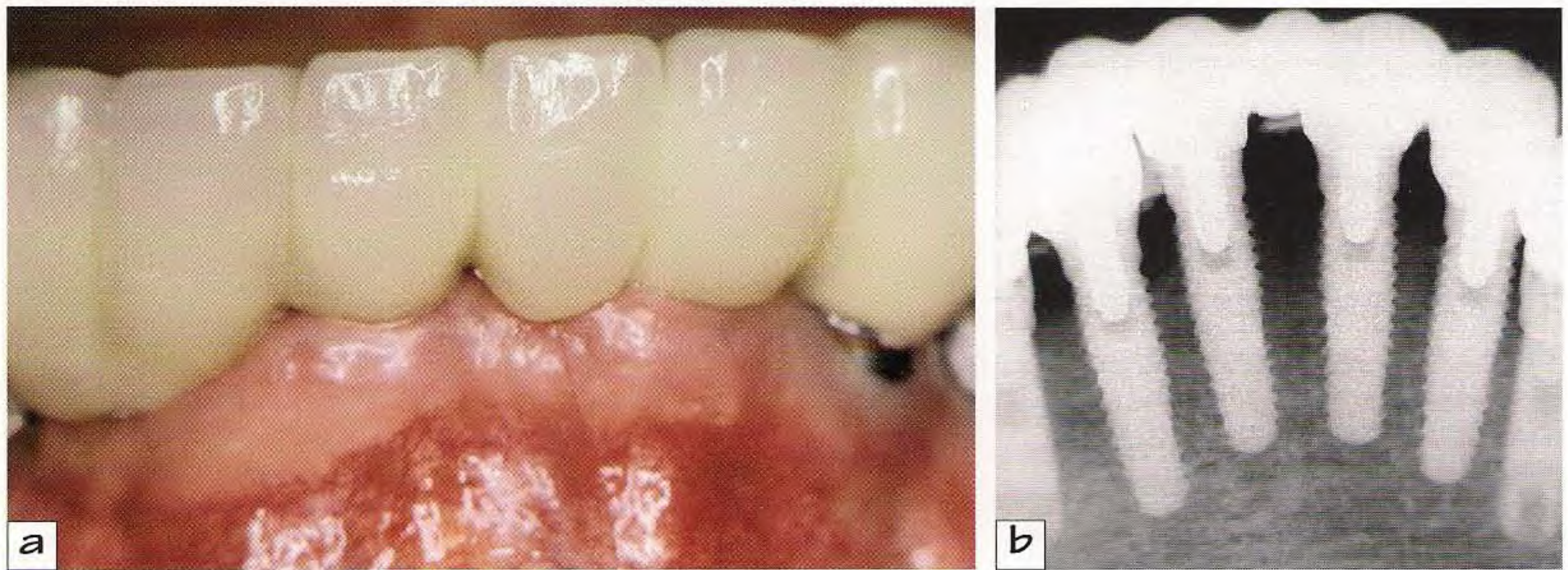
Complication during the surgical phase

Insufficient primary stability

If implants have inadequate primary stability of less than 35 Ncm, especially the most distal implants, it is advisable to abandon the immediate-loading procedure. It is still possible to consider



▲ Fig 13-14 Placement of the provisional prosthesis in the mouth 72 hours after surgery. (a) Clinical view 72 hours after surgery, before placement of the provisional prosthesis. (b) Abutments seated on the implants. (c) Buccal view of the provisional mandibular anterior prosthesis in the mouth. The esthetics is satisfactory even though the implants emerge in the embrasure spaces of the artificial teeth. Because of the advanced periodontal disease in the region, the implants had to be placed in that way to achieve good primary stability. (d) Provisional prosthesis in the mouth. Note the faint outline of the non-cast metal-reinforcement bar. (e) Prosthesis out of occlusion. (f) Buccal view of the prosthesis in place. The patient's high smile line partially reveals the provisional mandibular anterior prosthesis. (g) Radiograph taken with the prosthesis in place. Note the non-cast metal reinforcement bar and the titanium abutments. (Prosthesis by Dr M. Achour.)



▲ **Fig 13-15** Final prosthesis 12 months after placement. (a) Buccal view of the clinical situation. (b) Periapical radiograph. (Prosthesis by Dr M. Achour.)

substituting a longer or larger implant for the defective one. Even if the thickness of the buccal table is less than 1 mm, such an implant can be placed because the esthetic requirements are low or nonexistent in this region. Primary stability prevails over esthetic considerations in the anterior segment of the mandible.

Complications during the prosthetic phase

Complications common to all prosthetic options

- Hemorrhage during impression procedures.
- Rupture of sutures. Sutures may rupture during impression procedures or when the prosthodontist is attaching the prosthesis to the implant necks.
- Failure to achieve passive fit.

Complications specific to the screw-retained prosthetic option

Excessive buccal angulation of implants

When this happens, the access paths for the screws will emerge on the incisal edge or the labial surface of the crowns. The prosthodontist can mask these openings with a layer of resin composite and obtain a temporarily satisfactory result.

If this is not possible, the retention mode of the prosthesis will have to be changed to cementation. If titanium abutments are not available in the laboratory, immediate loading should be postponed for up to 72 hours.

Failure to achieve passive fit

This can be caused by a faulty impression or excessive shrinkage of the acrylic resin as it polymerized around the provisional cylinders.

Complications after delivery of the prosthesis

Complications common to all treatment options

Incomplete removal of impression material from gingiva

Inflammation of the gingiva can be caused by residual impression material trapped in crevices.

Fracture of the acrylic resin prosthetic teeth

When acrylic resin teeth fracture, the prosthodontist should check the occlusion of the prosthesis and eliminate the cause of the trauma. The laboratory can then readily repair the damage.

Complication specific to the screw-retained prosthetic options

- Loosening of cylinder screws

Complications specific to the cemented prosthetic options

- Loosening of abutment screws
- Debonding of prosthesis
- Incomplete removal of excess cement

Implant failures and alternative treatments

To date, the authors have not observed any implant failure during the provisional prosthetic phase of treatment in the anterior of the mandible.

Failure of an unessential implant

When the clinician determines that an implant that is not vital to the function of the prosthesis has become mobile, immediate action should be taken before resorption of the crestal bone takes place. The implant can be either removed or unloaded (see chapter 8). In either case, the prosthodontist fills the opening in the prosthesis over the implant with acrylic resin and returns the prosthesis to function. The remaining implants will be used for the final prosthesis.

Failure of an essential implant

When an implant vital to functioning of the prosthesis fails, it should be immediately replaced. If a larger and longer substitute can achieve a primary stability greater than 35 Ncm, the original site is reprepared and cleaned of all fibrous tissue. The new implant can be immediately loaded and the prosthesis can be returned to function.

If primary stability is inadequate, the failed implant can remain in place and left unburdened with a healing cap; this will shorten the overall treatment time. The prosthodontist then removes the fixed provisional prosthesis and places short healing abutments. Provisional restoration is continued with a removable partial denture until it is time to construct the final prosthesis.

Final prosthetic phase

The final prosthetic phase can begin as early as 2 months after placement of implants, but it can also be performed at a later time. When implants have been placed in extraction sites, a 3- to 4-month wait is advisable.

Implant osseointegration is verified radiographically and clinically. Radiographically, the absence of a dark, radiolucent area around the implant confirms osseointegration. Clinically, the implant is:

- Tested manually for mobility
- Assessed for the presence or absence of any clinical sign such as pain or local inflammation
- Tested with the application of a 20-Ncm counter torque
- Assessed with the Periotest or Osstell to measure implant stability (see chapter 4)

If the soft tissues are in good health without any other sign of pathology, the final prosthetic phase can start. The final prosthesis can be either screw retained or cemented.

The final screw-retained prosthesis can rest directly on the implant neck or on transgingival IOL abutments.

The prosthodontist completes the final prosthetic phase for the anterior segment of the mandible by removing the provisional prosthesis, screwing in the impression copings for implants or for abutments, taking an impression and a wax bite in the conventional manner, and sending these records to the laboratory. When the finished prosthesis returns from the laboratory, the prosthodontist places it in the patient's mouth, adjusts the occlusion, and takes a control radiograph.

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4. Del Fabbro M, Testori T, Francetti L, Taschieri S, Weinstein L. Systematic review of survival rates for immediately loaded dental implants. *Int J Periodontics Restorative Dent* 2006;26:249-263.

Chapter **14**

TREATMENT OF THE EDENTULOUS POSTERIOR MANDIBLE AND MAXILLA

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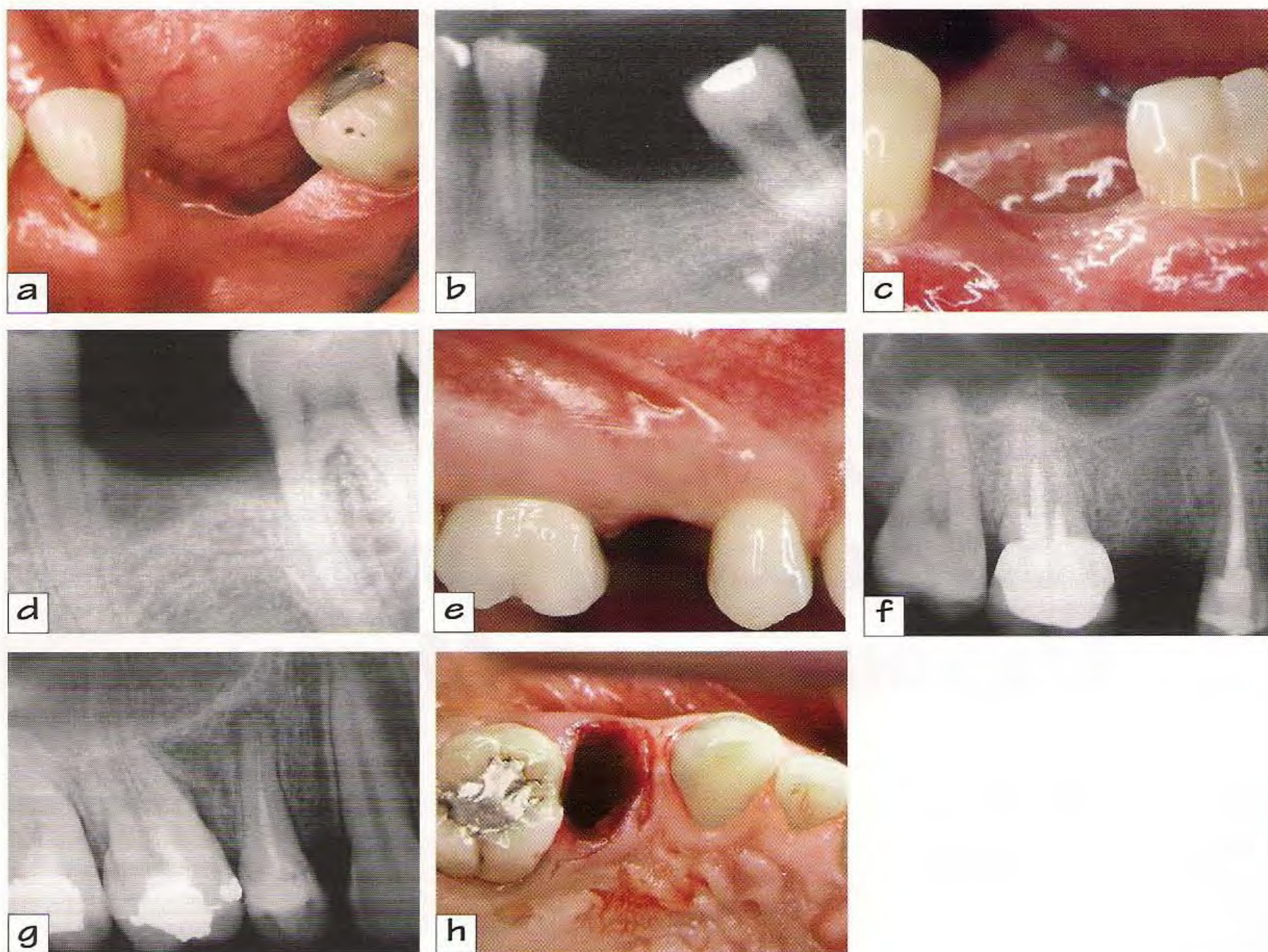
The final indication for the immediate-loading protocol includes the posterior segments of the mandible¹⁻¹² and the maxilla.^{8,11-24} In the maxilla, the premolars are frequently included in the smile line and therefore may belong to the esthetic area. This is much less common for the molars. Accordingly, the replacement of missing maxillary premolars was the first application of immediate-loading protocols in posterior maxillae to be reported in the literature. Some authors^{8,19} routinely include these cases in their discussion of the esthetic zone of the maxilla.

Following the successful application of immediate loading to the maxillary premolar region, some clinicians were emboldened to extend the use of immediate loading to the mandibular premolar area and then to molars.²⁻⁶ Not many clinicians have, as yet, reported on immediate loading of maxillary molars²⁻⁶; this fact is not surprising because the type of bone required for this procedure is rarely found in this segment. Those articles that have been published primarily describe treatment of edentulous spaces interposed between dental units.

To date the literature includes reports on about 72 single crowns and 180 implants supporting short, two-to-three-unit prostheses.¹² The single crowns have been followed for 6 months to 2 years, with an average success rate of 97.8%. For prostheses, the duration of follow-up ranges from 1 to 2 years, and the success rate is 94.8%.

Treatment of the posterior mandible or maxilla with immediate loading includes:

- Rehabilitation of healed sites that are located between dental units in the posterior mandible (Figs 14-1a to 14-1d)
- Rehabilitation of a combination of healed and extraction sites that are located between dental units in the posterior mandible



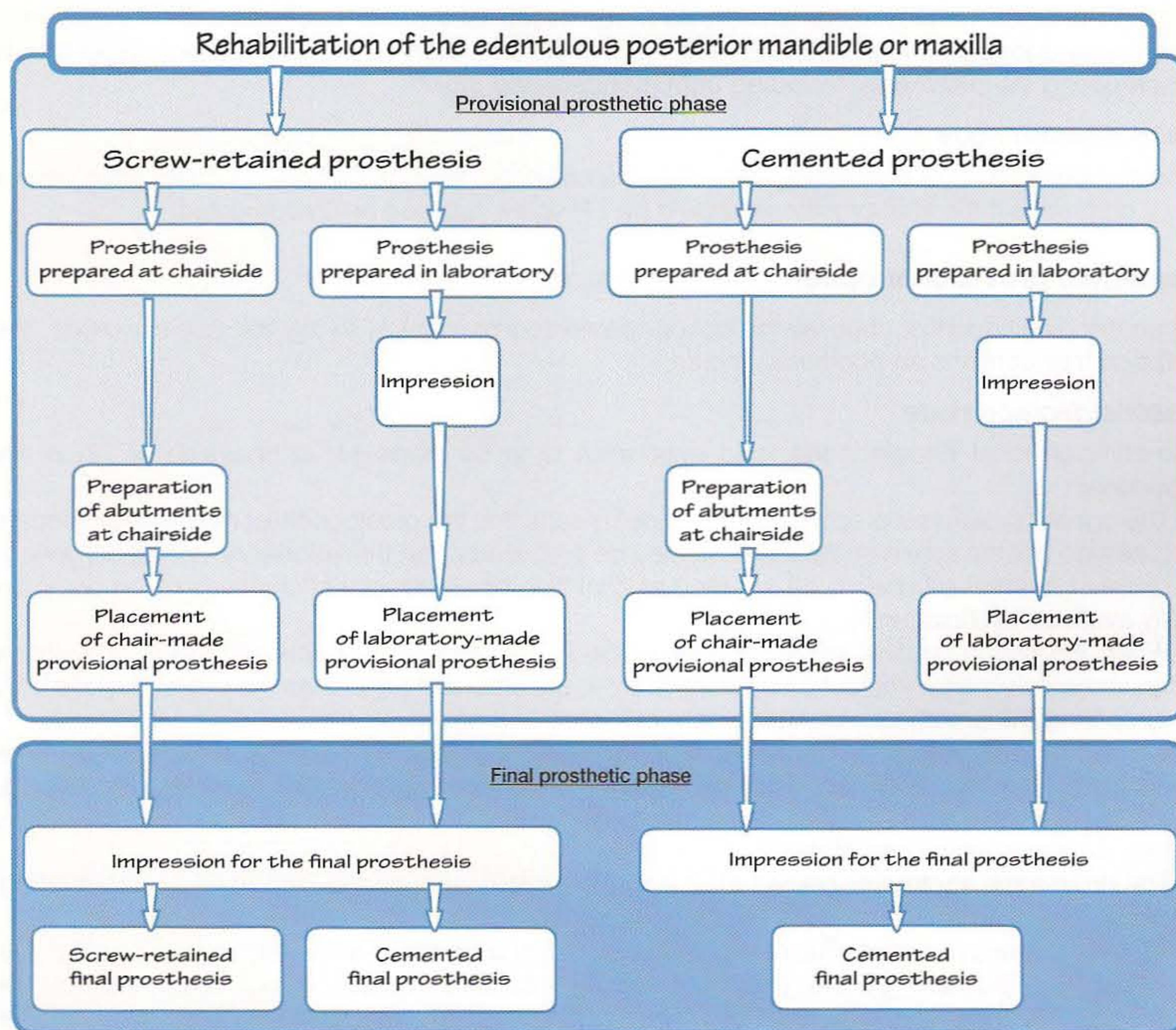
▲ **Fig 14-1** Clinical conditions included in the terms *edentulous posterior mandible* and *edentulous posterior maxilla*. (a and b) Premolar segment of the mandible with healed sites. (a) Edentulous area. (b) Preoperative radiograph. (c and d) Molar segment of the mandible with healed sites. (c) Edentulous area. (d) Preoperative radiograph. (e and f) Premolar segment of the maxilla with healed sites. (e) Edentulous area. (f) Preoperative radiograph. (g and h) Premolar section of the maxilla with extraction sites. (g) Preoperative radiograph showing the need for extraction. (h) Clinical view immediately after extraction.

- Rehabilitation of healed sites that are located between dental units in the posterior maxilla (Figs 14-1e and 14-1f)
- Rehabilitation of a combination of healed and extraction sites that are located between dental units in the posterior maxilla (Figs 14-1g and 14-1h)

Because the overall management of all these situations is similar, they have been grouped for discussion in the same chapter. However, their differences and specific challenges will be emphasized.

▼ Treatment Options

The range of options available for treatment of the posterior mandible or maxilla is outlined in Fig 14-2a in the form of a decision tree with successive decisions nodes. The decision tree is the same for both healed and extraction sites.



▲ **Fig 14-2a** Decision tree showing all treatment options available to rehabilitate the posterior mandible or maxilla. These options are common to healed and extraction sites.

Decision nodes

First decision node

The clinician first has to decide whether to use a (1) screw-retained prosthesis or (2) cemented prosthesis. The factors involved in this decision have been discussed in chapter 7.

Screw-retained provisional option

When the "screw-retained prosthesis" option is chosen, the prosthodontist continues on the tree with additional choices.

Second decision node

The clinician must decide if the fixed prosthesis is to be fabricated (1) at chairside or (2) in the laboratory.

The choice "prosthesis made at chairside" means that the prosthodontist prepares the cylinders at chairside. However, the crown or the multiunit prosthesis can still be made either (1) in the laboratory, before surgery, in the form of a hollowed shell to be adapted at chairside or (2) directly at chairside using commercially available artificial teeth.

When the option "provisional prosthesis made in the laboratory" is chosen, an impression is taken immediately after implant placement. From it, the laboratory assumes the entire responsibility for preparing the prosthesis, including both cylinders and crown.

Third decision node

After the completion of osseointegration and maturation of the soft tissues, the restorative dentist must determine if the final prosthesis should be (1) screw retained or (2) cemented.

Cemented provisional option

When the prosthodontist chooses the option "cemented prosthesis" in the first decision node, the decision tree contains an additional choice.

Second decision node

The clinician must decide if the fixed restoration is to be made (1) at chairside or (2) in the laboratory.

The option "prosthesis prepared at chairside" means that the prosthodontist makes the cylinders at chairside but the crown or the multiunit may be prepared (1) in the laboratory, before surgery, in the form of a hollowed shell to be adapted at chairside or (2) directly at chairside using commercially available artificial teeth.

When the option "provisional prosthesis made in the laboratory" is chosen, an impression is taken immediately after implant placement. From it, the laboratory assumes the entire responsibility for preparing the prosthesis, including both cylinders and crown.

Whichever pathway is chosen, after the prosthesis has functioned for 2 or 3 months in the mandible, which corresponds to the time required for osseointegration, or 6 months in the maxilla, which is the time required for maturation of the soft tissues, the clinician evaluates implant stability before starting construction of the final restoration.

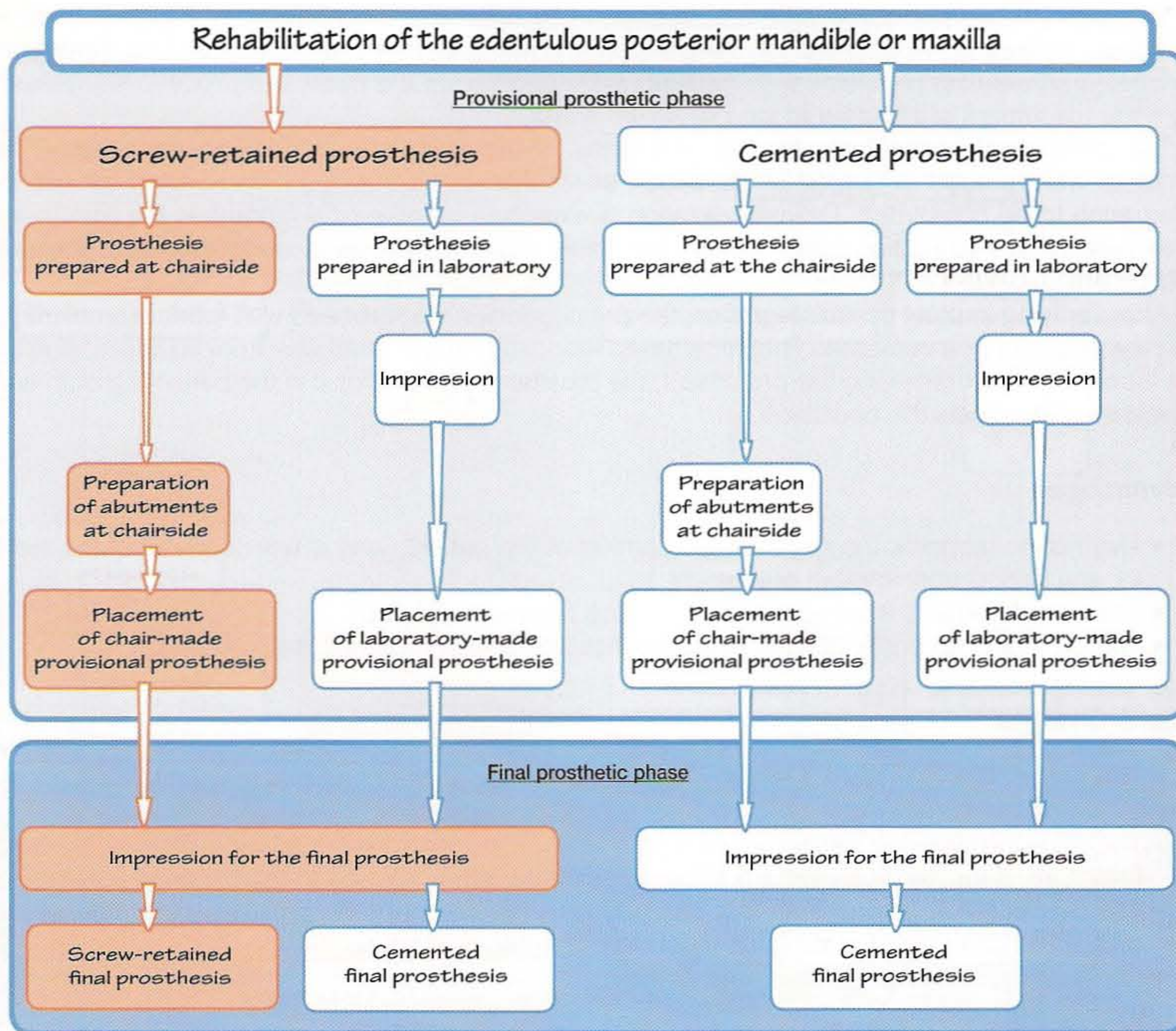
The provisional abutments placed after surgery are removed, and an impression is taken of the necks of the implants and sent to the laboratory for fabrication of the final cemented prosthesis.

To meet esthetic requirements, it may be decided, just as in the anterior maxilla (see chapter 11), to avoid manipulation of the prosthetic abutments and thereby avoid disruption of the mucoepithelial attachment. If this option has been decided, abutments at sites with gingival recession will be trimmed in the mouth to adapt to the new gingival margins, in the same way that natural teeth are prepared for crowns and fixed partial dentures.

The various treatment options for the posterior maxilla and mandible will be considered in the following sections.

Treatment options for rehabilitation of the posterior edentulous mandible and maxilla

- Option 1:** A screw-retained provisional prosthesis is placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the cylinders are prepared at chairside.
- Option 2:** A screw-retained provisional prosthesis is placed within 24 to 48 hours after surgery; the prosthesis is fabricated entirely in the laboratory.
- Option 3:** A cemented provisional prosthesis is placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the abutments are prepared at chairside.
- Option 4:** A cemented provisional prosthesis is placed within 24 to 48 hours after surgery; provisional abutments and the prosthesis are prepared in the laboratory.



▲ **Fig 14-2b** Treatment option for rehabilitation of the posterior mandible or maxilla when a screw-retained provisional prosthesis is preferred and the principal determinant of treatment is the psychologic needs of the patient. The sequence of steps is indicated in red. With this option, the final prosthesis can be either screw retained or cemented.

Treatment option I

Screw-retained provisional prosthesis placed immediately after surgery; the hollowed prosthesis is made in the laboratory before surgery and the cylinders are prepared at chairside.

This option (Fig 14-2b) is chosen when:

- A screw-retained prosthesis is preferred to a cemented prosthesis.
- The implants' axes are compatible with occlusal emergence of the screw access paths.
- The psychologic comfort of the patient is the principal determinant of treatment. In this case, the patient who would be uncomfortable being edentulous is able to leave the office after surgery wearing an immediate replacement for the absent dentition.

For this option, the laboratory makes shell teeth in advance, and the clinician attaches them to the provisional cylinders, which are prepared at chairside. Treated in one session, the patient leaves the office with the fixed provisional prosthesis in place.

The clinician can perform a variant of this option by hollowing a commercially available tooth at chairside instead of having the laboratory prepare a replacement in advance. This approach eliminates scheduling problems with the laboratory and allows the patient to proceed seamlessly from the placement of implants to the prosthetic phase.

The provisional phase lasts for 2 to 4 months in the mandible, depending on whether the implants were placed in healed or extraction sites; this represents the time needed for osseointegration to be completed. Provisionalization is extended for at least 6 months in the maxilla for both healed and extraction sites. During this time, osseointegration is completed and the soft tissues are stabilized.

After verifying implant osseointegration, the prosthodontist can proceed with fabrication of either a screw-retained or a cemented final prosthesis, fabricated in the usual way from an impression by the laboratory. After receiving the prosthesis, the prosthodontist places it in the patient's mouth and assesses and adjusts the occlusion.

Advantages

- This option respects the psychologic comfort of the patient, who is not deprived of the teeth for any period after implant placement.
- The use of cement, which can irritate the soft tissue, is avoided.
- The clinician can easily unscrew the prosthesis to check implant osseointegration.

Disadvantages

- The patient has to endure a lengthy combined session in the chair that may last 2 to 4 hours, including the surgery and the consecutive prosthetic phase.
- The clinician and the assisting team also endure a lengthy care session of 2 to 4 hours, especially if the surgical and prosthetic phases are carried out by the same practitioner.
- The overall fee is greater than that charged for a laboratory-made prosthesis because of the protracted chair time the clinician must devote to the procedure.
- The screw-retained prosthesis may loosen.

Treatment tip:

- This protocol should be chosen if a screw-retained provisional restoration is preferred and the patient does not want to be deprived of a restoration, even for a brief period, especially in the maxillary premolar area.
- For patients who are not as demanding in this regard, a laboratory-made prosthesis simplifies the procedure for both the patient and the practitioner.

Treatment option 2

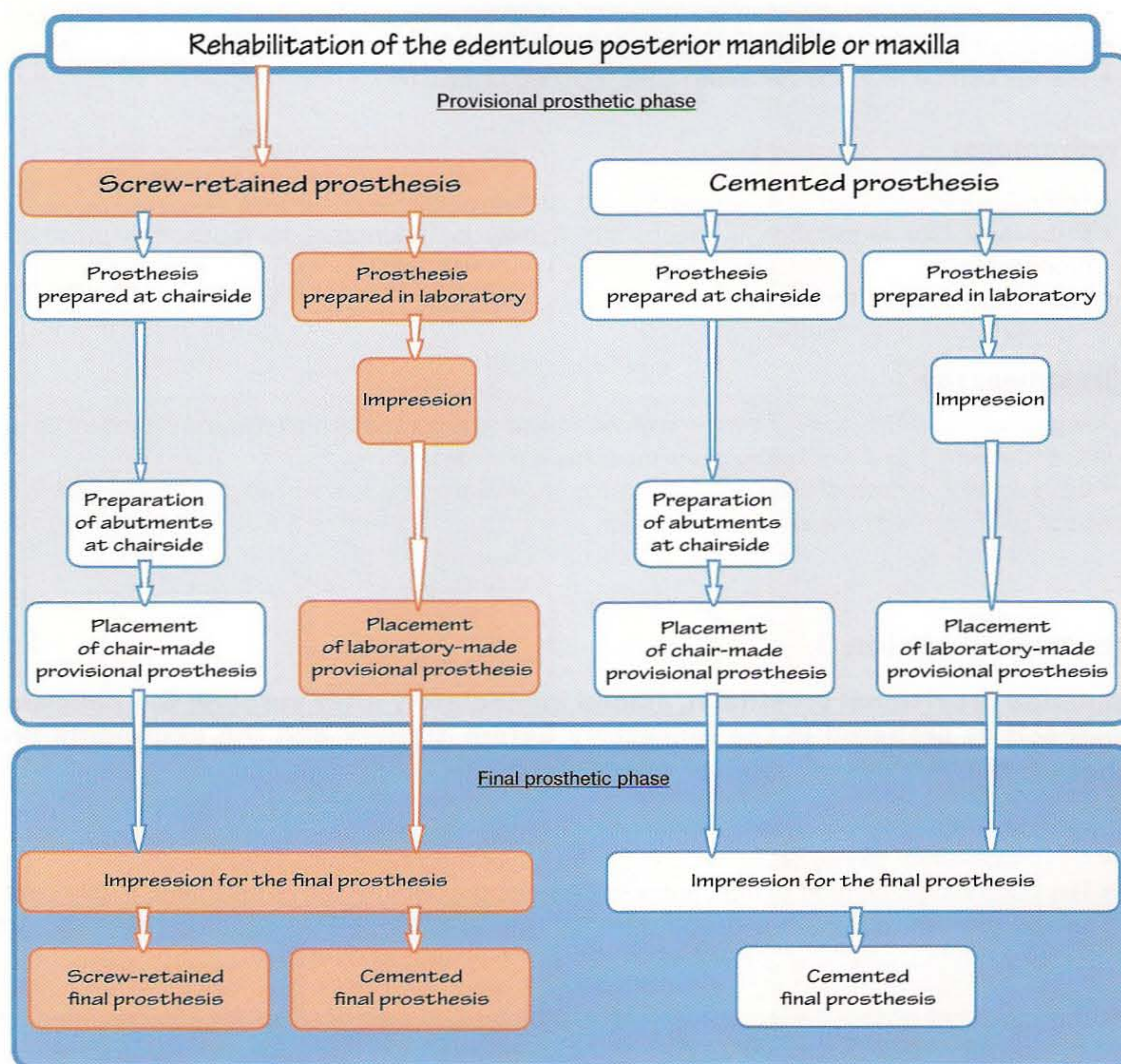
Screw-retained provisional prosthesis placed within 24 to 48 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

This option (Fig 14-2c) is chosen when:

- A screw-retained prosthesis is preferred to a cemented prosthesis.
- The implants' axis are compatible with occlusal emergence of the screw access paths.
- The physical comfort of the patient is the principal determinant of treatment. The patient does not want to endure a long session in the dental chair.
- It is desirable, for whatever reasons, to have the laboratory fabricate the prosthesis.

In contrast to the preceding option, in this option the prosthesis is entirely made in the laboratory. The patient is treated in two distinct sessions and receives the restoration within 48 hours after surgery.

The provisional phase lasts for 2 to 4 months in the mandible, depending on whether the implants were placed in healed or extraction sites, which is the time needed for osseointegration to be



▲ **Fig 14-2c** Treatment option for rehabilitation of the posterior mandible or maxilla when a screw-retained provisional prosthesis is preferred and the principal determinant of treatment is the physical comfort of the patient. The sequence of steps is indicated in red. With this option, the final prosthesis can be either screw retained or cemented.

completed. The provisional prosthesis functions for at least 6 months in the maxilla for both healed and extraction sites. During this time, osseointegration is completed and the soft tissues are stabilized.

After implant osseointegration is verified, either a screw-retained or cemented final prosthesis is made by the laboratory in the usual way from an impression. After the prosthesis is delivered, the prosthodontist places it in the patient's mouth and assesses and adjusts the occlusion.

Advantages

- This protocol respects the physical comfort of the patient. The patient only has to endure the surgery in the dental chair. Because the laboratory constructs the prosthesis, 1 or 2 hours of chair time can be eliminated.
- The use of cement, which can irritate the soft tissue, is avoided.

- If necessary, the clinician can easily unscrew the prosthesis to check implant osseointegration.
- The prosthodontist is spared a long and often tedious session at chairside.
- The fee can be reduced because of the reduced chair time.

Disadvantages

- The patient is deprived of a restoration for 1 or 2 days following surgery.
- If the wax bite registration is inaccurate, it may be necessary to repeat the prosthetic procedures.
- The screw-retained prosthesis may loosen.

Treatment tip:

- This protocol should be chosen if a screw-retained provisional restoration is preferred and the patient does not mind waiting 1 to 2 days before a new prosthesis is provided.
- If the restoration consists of two or more units, this option is the best and most efficient way to treat this type of edentulism with a screw-retained solution.

Treatment option 3

Cemented provisional prosthesis placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the abutments are prepared at chairside.

This option (Fig 14-2d) is chosen when:

- A cemented provisional prosthesis is preferred over a screw-retained prosthesis.
- The psychologic comfort of the patient is the principal determinant of treatment. In this case, the patient who would be uncomfortable being edentulous is able to leave the office after surgery wearing an immediate replacement for the absent tooth or teeth.

In this treatment option, the laboratory makes shell teeth in advance and the clinician attaches them to the provisional cylinders prepared at chairside. Treated in one session, the patient leaves the office with the provisional fixed prosthesis in place.

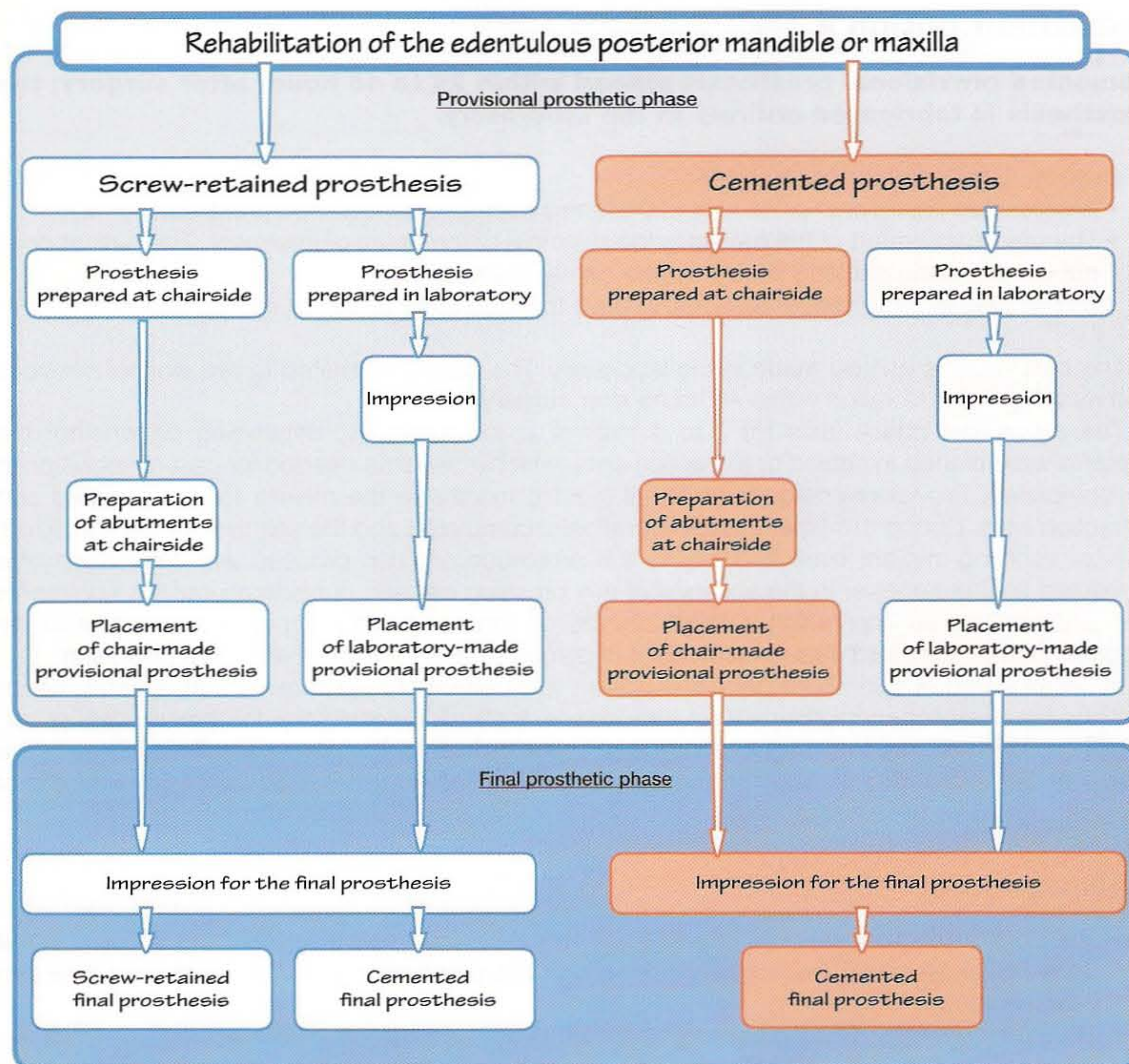
In a variant of this procedure, the prosthodontist constructs the prosthesis by hollowing out a commercial denture tooth or teeth at chairside without asking the laboratory to participate. The advantage of this approach is the elimination of the need to coordinate the procedure with a third party, the laboratory technician. However, this alternative does require additional chair time on the part of the prosthodontist.

The provisional phase lasts for 2 to 4 months in the mandible, depending on whether the implants were placed in healed or extraction sites; this is the time needed for osseointegration to be completed. The provisional phase lasts for at least 6 months in the maxilla for both healed and extraction sites. During this time, osseointegration is completed and the soft tissues are stabilized.

After verifying implant osseointegration, the prosthodontist can proceed with fabrication of either a screw-retained or cemented final prosthesis made in the usual way from an impression by the laboratory. After the prosthesis is delivered, the prosthodontist places it in the patient's mouth and assesses and adjusts the occlusion.

Advantages

- This option respects the psychologic comfort of the patient, who is not deprived of teeth for any period after implant placement.
- A cemented prosthesis closely approximates the classic conditions of restoration with a "crown and bridge" on natural teeth.
- There is a greater tolerance for the lack of implant parallelism.



▲ **Fig 14-2d** Treatment option for rehabilitation of the posterior mandible or maxilla when a cemented provisional prosthesis is preferred and the principal determinant of treatment is the psychologic needs of the patient. The sequence of steps is indicated in red. With this option, the final prosthesis is cemented.

Disadvantages

- The patient has to endure a lengthy combined session in the chair that may last 2 to 3 hours, including the surgery and the consecutive prosthetic phase.
- Excess cement can be trapped in the gingiva.
- The overall fee is greater than that charged for a laboratory-made prosthesis because of the protracted chair time the clinician must devote to the procedure.
- The cemented prosthesis can debond.

Treatment tip:

- This protocol should be chosen if a cemented provisional restoration is preferred and the patient does not want to be deprived of a restoration, even for a brief period, especially in the maxillary premolar area.
- For patients who are not as demanding in this regard, a laboratory-made prosthesis simplifies the procedure for both the patient and the practitioner.

Treatment option 4

Cemented provisional prosthesis placed within 24 to 48 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

This option (Fig 14-2e) is chosen when:

- A cemented provisional prosthesis is preferred over a screw-retained prosthesis.
- The physical comfort of the patient is the principal determinant of treatment. The patient does not want to endure a long session in the dental chair.
- It is desirable, for whatever reasons, to have the laboratory fabricate the prosthesis.

The prosthesis is entirely made in the laboratory. The patient is treated in two distinct sessions and receives the restoration within 48 hours after surgery.

The provisional phase lasts for 2 to 4 months in the mandible, depending on whether the implants were placed in healed or extraction sites, which is the time needed for osseointegration to be completed. Provisionalization lasts for at least 6 months in the maxilla for both healed and extraction sites. During this time, osseointegration is completed and the soft tissues are stabilized.

After verifying implant osseointegration, the prosthodontist can proceed with fabrication of a cemented final prosthesis. In the absence of any pressing esthetic considerations, the abutments are removed and an impression is taken directly on the neck of the implants and sent it to the laboratory. After the prosthesis is received, it is placed to verify the passive fit and occlusion.

In cases where esthetic considerations prevail, it is better not to unscrew the abutments, which disturbs the established mucoepithelial attachment. Instead, if necessary, the prosthodontist can adjust the coronal margins of the abutments in the mouth in the same way natural teeth are prepared. An impression is taken on the abutments and sent to the laboratory for construction of the final prosthesis in the usual way.

Advantages

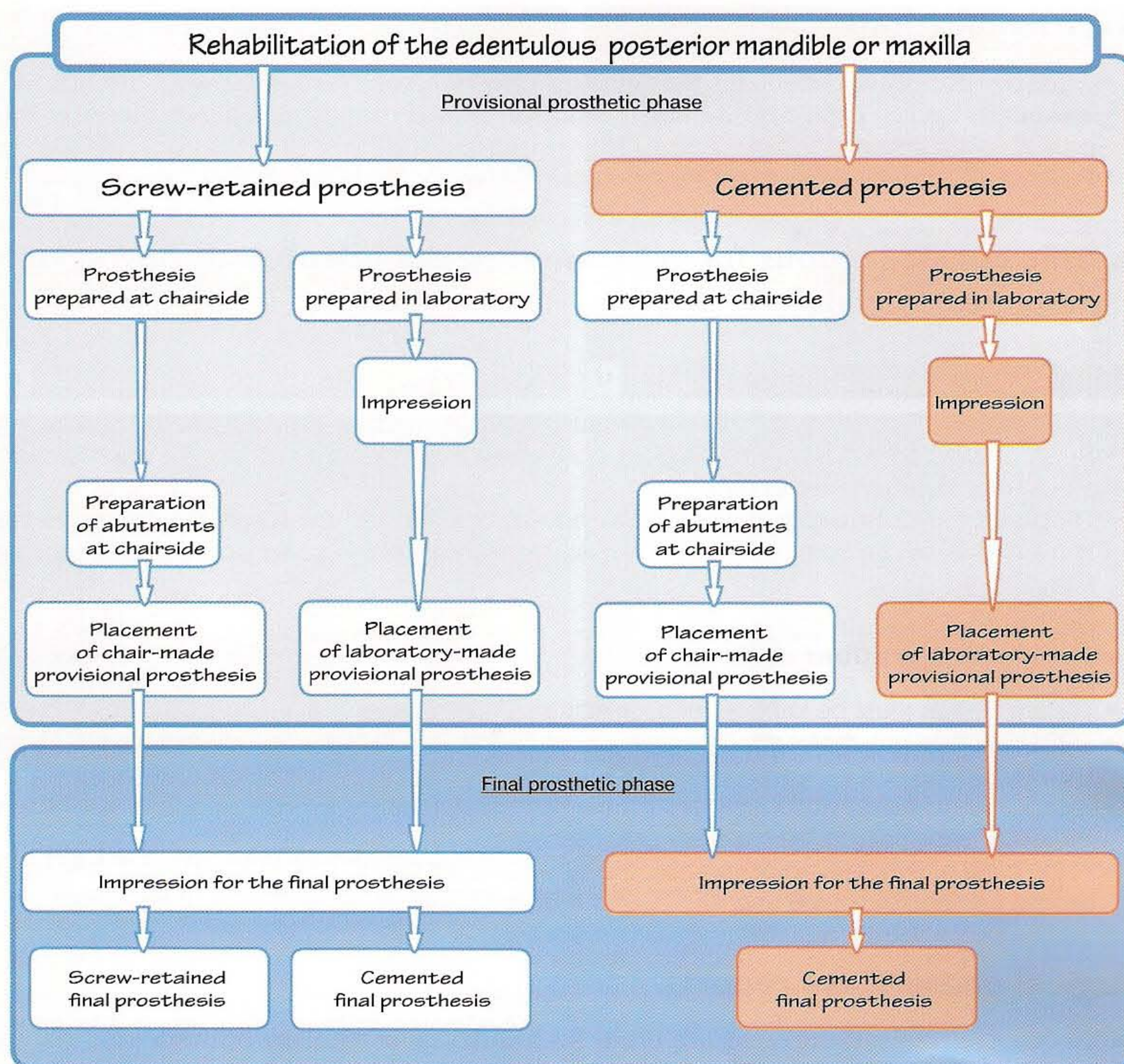
- The comfort of the patient is respected. The patient has only to endure the surgery in the dental chair. Because the laboratory constructs the prosthesis, 1 or 2 hours of chair time can be eliminated.
- The prosthodontist is spared a long and often tedious session at chairside.
- The fee can be reduced because chair time for the prosthodontist is reduced.
- There is a greater tolerance for lack of parallelism of implants.

Disadvantages

- The patient is deprived of a restoration for 1 or 2 days following surgery.
- If the wax bite registration is inaccurate, the prosthetic procedure may have to be repeated.
- Excess cement can be trapped in the gingiva.
- The cemented prosthesis can debond.

Treatment tip:

- This protocol should be chosen if a cemented provisional restoration is preferred and the patient does not mind waiting 1 to 2 days before receiving a new prosthesis.
- If the restoration consists of two or more units, this option is the best and most efficient way to treat this type of edentulism with a cemented restoration.



▲ **Fig 14-2e** Treatment option for rehabilitation of the posterior mandible or maxilla when a screw-retained provisional prosthesis is preferred and the principal determinant of treatment is the physical comfort of the patient. The sequence of steps is indicated in red. With this option, the final prosthesis is cemented.

▼ Step-by-Step Guidelines for Immediate-Loading Treatment of the Posterior Mandible or Maxilla

Indications

- Available bone height at implant site: ≥ 11.5 mm
- Available bone width at implant site: ≥ 5.5 mm
- Bone quality: dense or normal (types 1 to 3)
- Number of implants: 1 to 3
- Insertion torque of each implant: ≥ 40 Ncm

Contraindications

- If primary stability is inadequate, the immediate-loading protocol must be discontinued.
- Immediate loading should not be attempted if the crowns cannot be kept out of occlusion in protrusive excursions.
- Patients who exhibit bruxism are not good candidates for immediate loading.

Specific considerations for treatment of the edentulous posterior mandible or maxilla

Surgical considerations

- It is occasionally difficult to obtain satisfactory primary stability, especially in the maxilla.
- Rules of three-dimensional (3D) implant positioning must be followed closely when esthetic requirements prevail (see chapter 5).
- For prospective screw-retained crowns or multi-unit prostheses, the surgeon must ensure that implant axes will be compatible with occlusal emergence of the screw access holes (options 1 and 2).

Prosthetic considerations

- The prosthesis must be kept out of occlusion.
- The provisional prosthesis must provide guidance and encourage maturation of the soft tissue (see chapter 6).
- It might be difficult to accurately predict the soft tissue reaction in order to obtain satisfactory esthetics, especially in the maxillary premolar area.
- In the case of a cemented restoration, the clinician must spend time in scrupulous removal of excess cement (options 3 and 4).

Surgical phase: Case reports

The treatment options and the prosthetic phase for mandibular or maxillary posterior sites that are edentulous or that will be edentulous after extraction are identical; only the surgical phase differs. Various surgical situations will be presented but with only one case for each prosthetic option.

Replacement of teeth in maxillary posterior healed site

Presurgical preparation

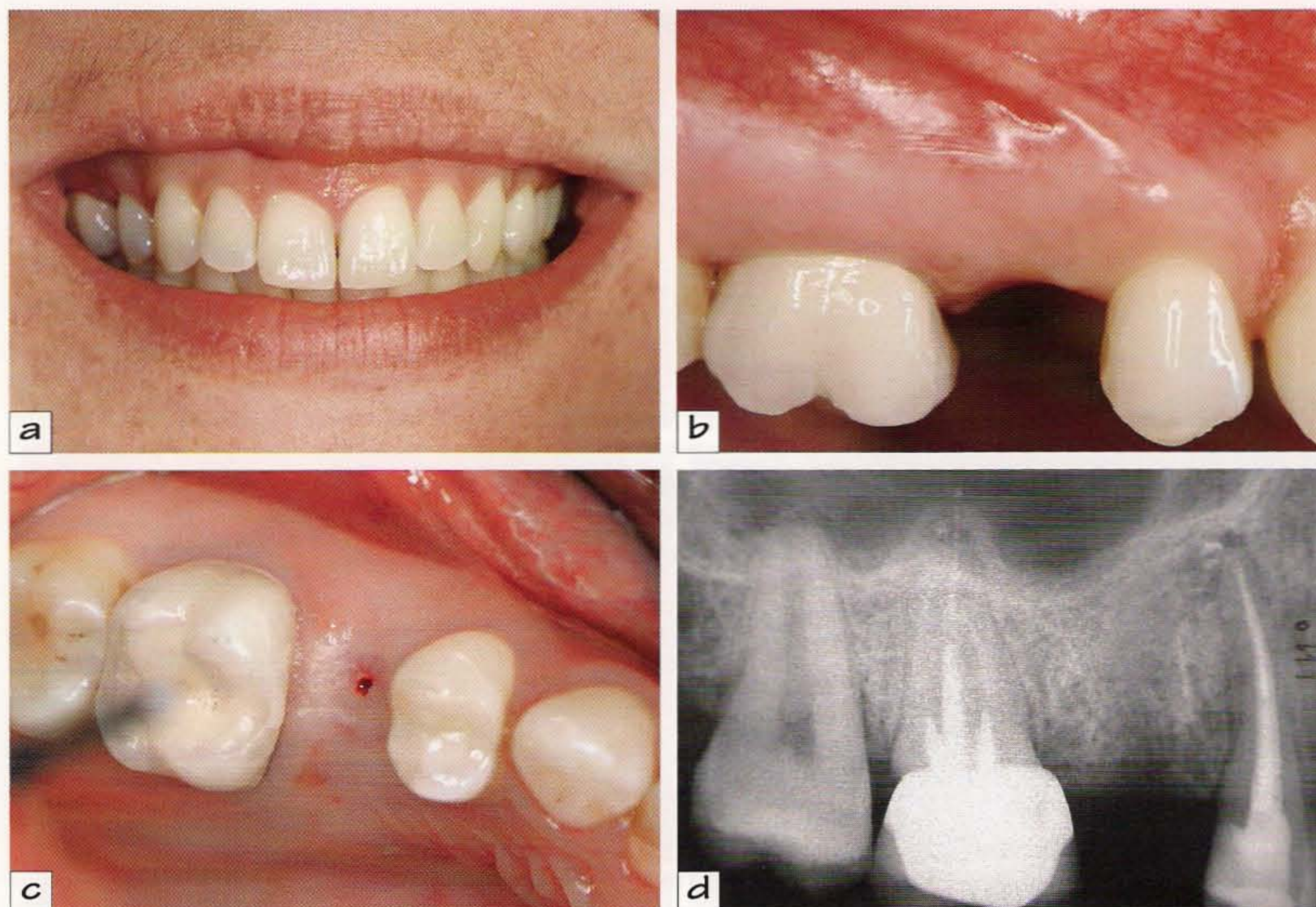
A young woman presented for the replacement of a missing maxillary premolar in a healed site. She wanted to replace her removable partial denture with a fixed prosthesis and, for reasons associated with her professional responsibilities, asked for the restoration to be completed as quickly as possible.

Clinical examination

- Determination of the smile line (Fig 14-3a)
- Assessment of the status of the soft tissues, the relationship between the cervical margin of the tooth to be restored and its adjacent teeth or crowns, and the presence and quality of the papillae (Fig 14-3b)
- Evaluation of the width of the ridge (Fig 14-3c)

Radiographic examination

The available bone height is determined from the periapical radiograph (Fig 14-3d).



▲ **Fig 14-3** Presurgical examination. (a) Determination of the smile line. The premolars clearly participate in the esthetics of this young woman's generous smile. Her smile line is high and exposes the necks of the maxillary teeth. Esthetics will definitely be an important consideration when her missing maxillary premolar is restored. (b) Determination of esthetics associated with the soft tissues. The patient's periodontal biotype is thin and the necks of the teeth are low, providing some flexibility for achieving esthetics. (c) Assessment of the width of the ridge. It appears to be adequate. A periapical radiograph will provide indispensable information about the nature of the adjacent osseous structures. (d) Periapical radiograph. The bone available beneath the maxillary sinus is sufficient to host a 13-mm implant.

Study casts: Preparation of a surgical guide

The surgical guide is restrictive and demarcates the mesiodistal and buccopalatal axes of the implant (Fig 14-4a).

An implant of standard diameter placed in the center of the ridge will satisfactorily maintain a 2-mm distance between its external border and the buccal plate.

Surgical phase

Placement of implants

Selection of implant design.

1. *Implant design and diameter.* In this region, the choice of implant should be driven by the ability to obtain good primary stability and an acceptable esthetic response from the soft tissues. For this patient, an Osseotite XP implant (Biomet 3i) with a wide neck was chosen; the implant body was 4 mm in diameter and the neck was 5 mm in diameter; the implant was positioned subcrestally.

2. *Implant length.* The radiographic analysis showed that sufficient bone was available to support a 13-mm-long implant.

Preparation of osseous sites. To respect esthetic requirements and because the ridge was wide enough in this patient, the surgeon gained access to the bone directly without raising a flap (see Fig 14-4a). The shaft of the round bur was rested against the surgical guide to determine the correct point of entry. The initial preparation was followed by a graduated sequence of burs (Fig 14-4b).

Drilling sequence. The drilling sequence was carried out in the usual way without tapping of the site.

3D implant positioning.

1. *Mesiodistal axis.* Indicated by the surgical guide, the mesiodistal axis is parallel to the crown to be supported by the implant (Figs 14-4b to 14-4d).
2. *Buccolingual axis.* The position of the implant on the ridge should leave the desirable 2-mm distance between the edge of the implant and the external edge of the buccal plate. The long axis of the implant, directed by the surgical guide, will emerge through the occlusal surface of the crown.
3. *Coronoapical axis.* To respond to esthetic requirements, the neck of the implant must be positioned 2 mm below the cemento-enamel junctions of the adjacent teeth. In this case, the subcrestal placement of the implant met this requirement.

Primary stability. The implant was fully seated in the prepared alveolus with a torque regulated at 45 Ncm (Figs 14-4d and 14-4e).

Use of bone profiler. The bone profiler was not needed for this implant.

Placement of healing abutment. The healing abutment is screwed into position (Fig 14-4f). The prosthetic phase follows implant placement immediately; even if both phases are performed by the same practitioner, a healing abutment must be placed to prevent the soft tissues from collapsing.

Suturing. This procedure requires no suturing.

Control radiograph. A periapical radiograph is taken to ensure that the implant is correctly placed in a subcrestal position (Fig 14-4g).

Transition from surgical treatment site to prosthetic treatment site. The transition from the surgical treatment site to the prosthetic treatment site should be planned in advance to avoid any misunderstandings and to ensure that the patient experiences a seamless transition from the surgical phase to the prosthetic phase.

The prosthetic phase is discussed later in the chapter, after a description of the surgical approach to manage posterior partial edentulism in a combination of healed and extraction sites.

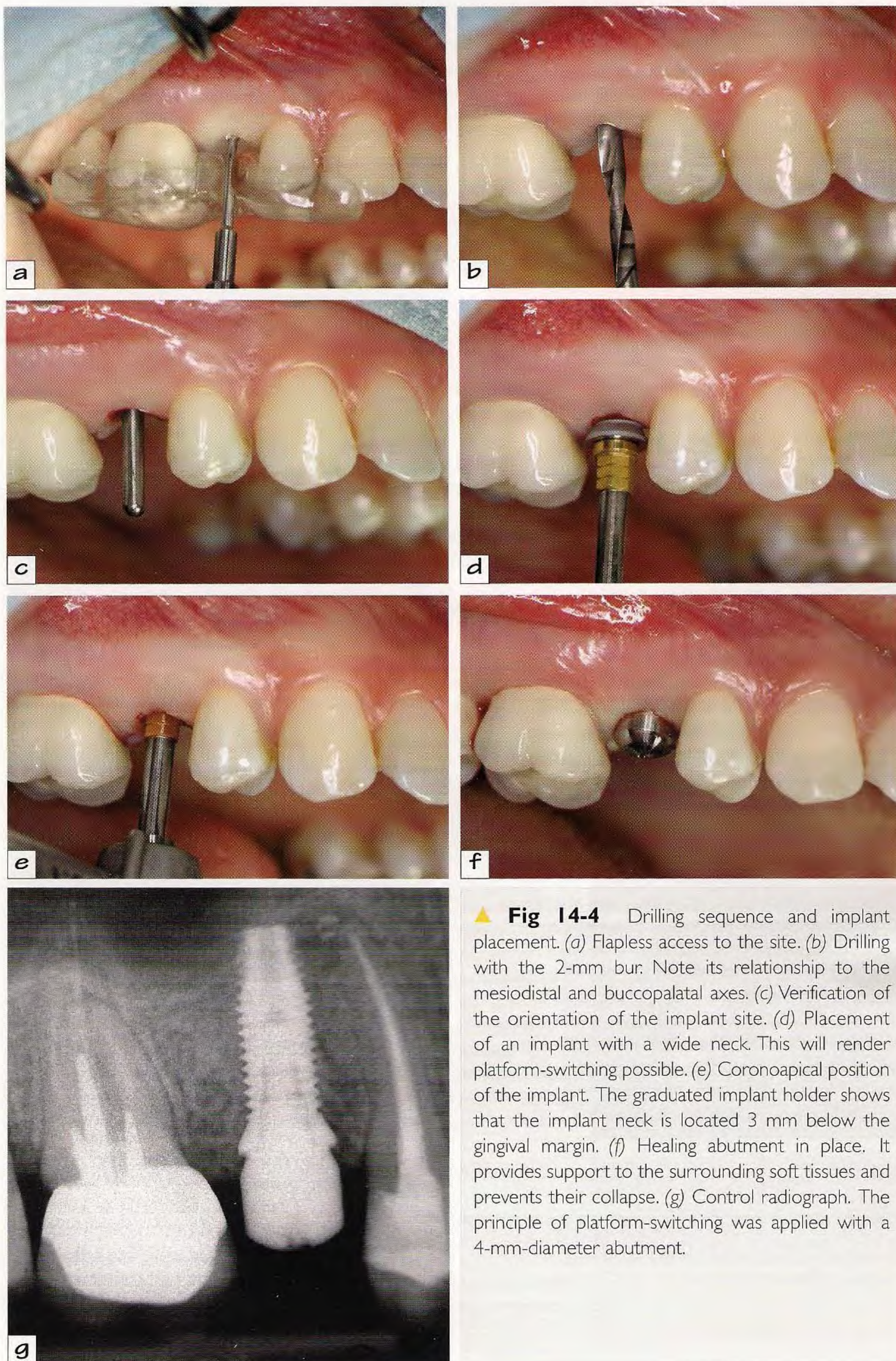
Replacement of teeth in a combination of mandibular posterior healed and extraction sites

A longitudinal crack had developed in the root of a premolar that served as the anterior abutment of a three-unit posterior prosthesis; the extent of the crack necessitated extraction of the tooth (Figs 14-5a and 14-5b). The patient, a woman in her mid 50s, wanted the resultant edentulous area to be restored as quickly as possible.

Presurgical preparation

Clinical examination

In the posterior segment of the mandible, there are no critical esthetic requirements. The initial assessment is therefore limited to an evaluation of the available bone volume.



Radiographic examination

The height and depth of the osseous site are determined with the aid of a periapical radiograph (see Fig 14-5a) and oblique sections from a computerized tomographic (CT) scan (Fig 14-5c). In this case, the CT indicated that the bony crest was sufficiently spacious to receive an implant; it also confirmed the measurement of the available bone height already made from the periapical radiograph and also revealed the location of the mandibular canal.

Surgical phase

Extraction of tooth

The premolar was removed in an atraumatic procedure (Fig 14-6a).

Placement of implants

Selection of implant design.

1. *Implant design and diameter.* For this mandibular site, conical or wide-neck implants with or without platform-switching capability promised the highest primary stability. Wide-neck conical Osseotite XP implants with a body of 4 mm in diameter and a neck of 5 mm in diameter were selected.
2. *Implant length.* For this patient, 13-mm-long implants were compatible with the available bone height, including a 2-mm security distance above the mandibular canal (see Fig 14-6f).

Preparation of osseous sites. A flap is raised without a releasing incision; the flap provides adequate direct visual access for secure implant placement.

Drilling sequence. The drilling sequence is carried out in the usual way without tapping.

3D implant positioning.

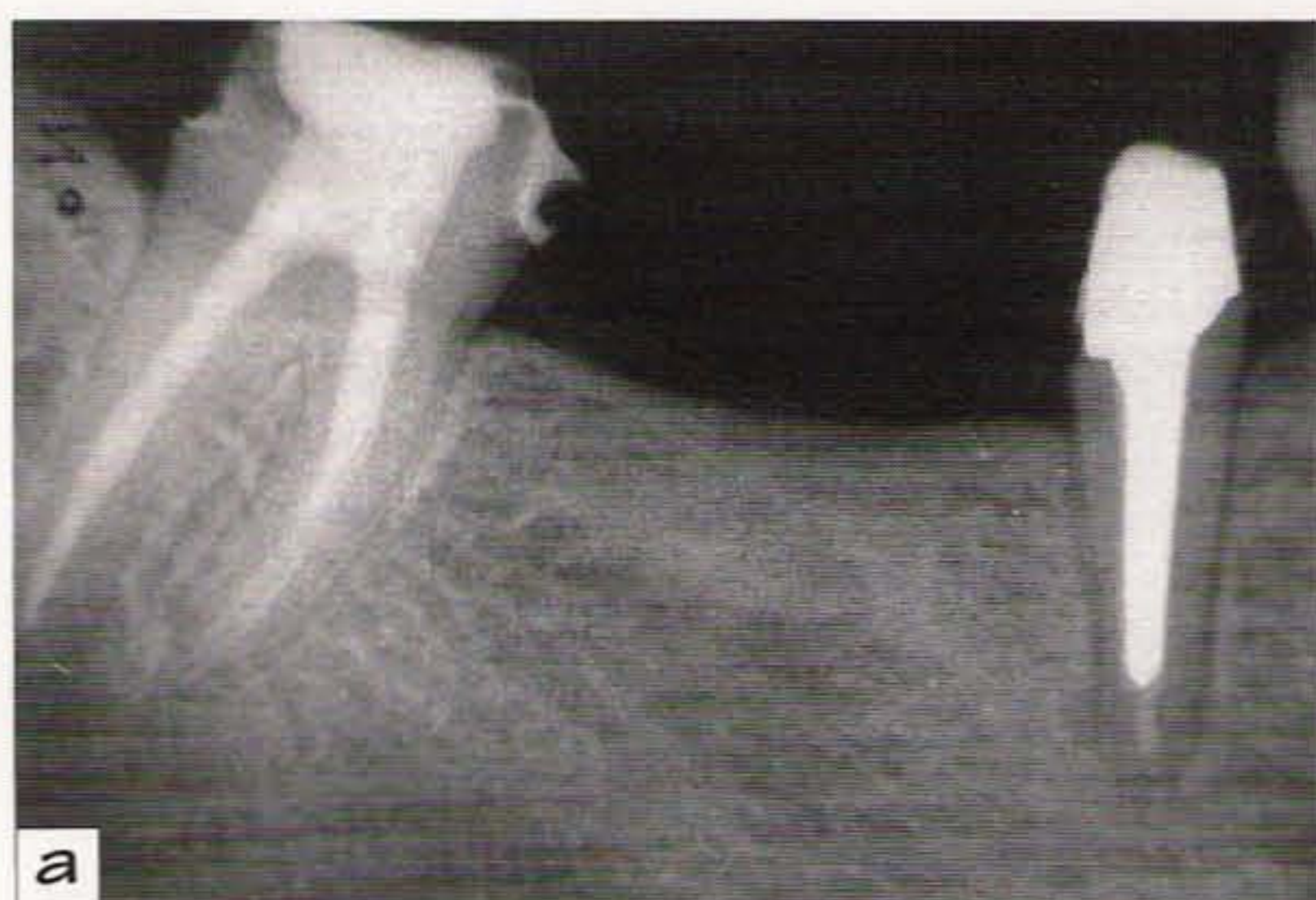
1. *Mesiodistal axis.* In the restoration of the healed molar site, the implant axis is perpendicular to the breadth of the supported artificial tooth (Figs 14-6b and 14-6c). In the premolar extraction socket, the implant positioning does not follow the tooth axis. It is angulated in the distal direction to improve primary stability.
2. *Buccolingual axis.* The implant in the distal healed site is placed in the center of the ridge (Fig 14-6d). The implant placed in the extraction site is fitted in the center of the alveolus.
3. *Coronoapical axis.* In this case, the wide-neck implants were positioned subcrestally (Fig 14-6d), but they can also be placed level with the crest. A supracrestal position is avoided in order to leave sufficient height for development of a harmonious emergence profile. Implants placed in extraction sites are also positioned subcrestally. This position increases the primary stability of the implant by deriving support from the walls of the alveolus (Fig 14-6d).

Primary stability. Implants are placed with a torque ≥ 40 Ncm.

Placement of healing abutments. The healing abutments are screwed in position. In this case, the posterior abutment, 6 mm in diameter, was larger than the implant neck; the objective was to immediately start shaping the emergence profile of the molar. For the same reason, the anterior premolar abutment was narrower than the wide-neck implant; furthermore, the difference introduced a platform-switching effect.

Suturing. The gingiva is sutured around the abutments (Fig 14-6e).

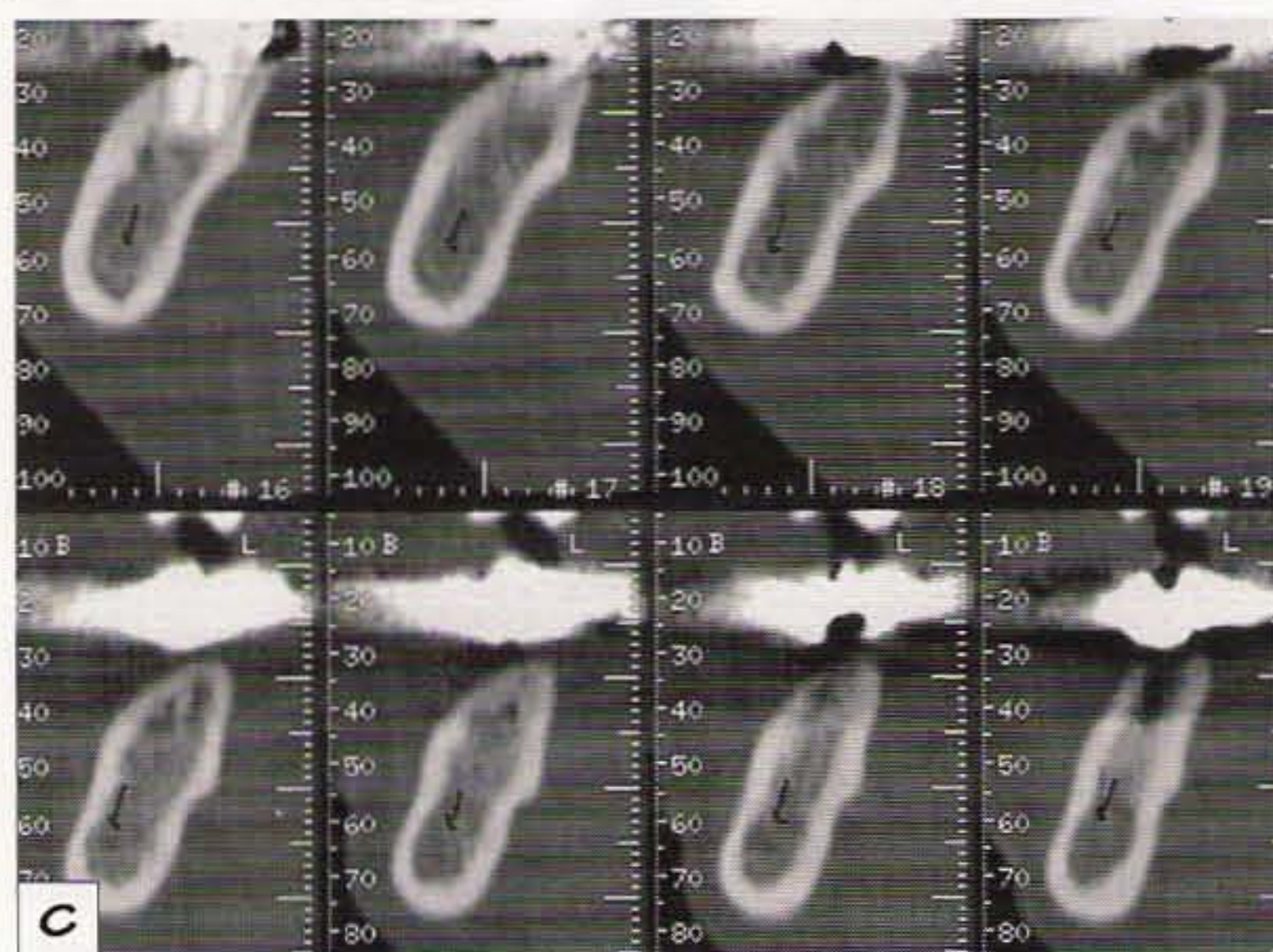
Control radiograph. A periapical radiograph is taken to ensure that the implants are properly placed in their predetermined positions (Fig 14-6f).



a

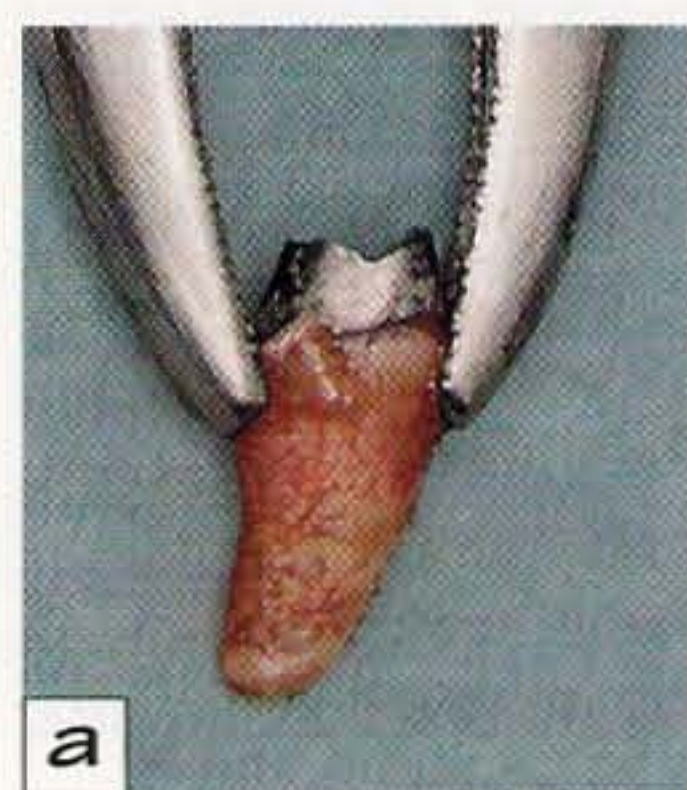


b

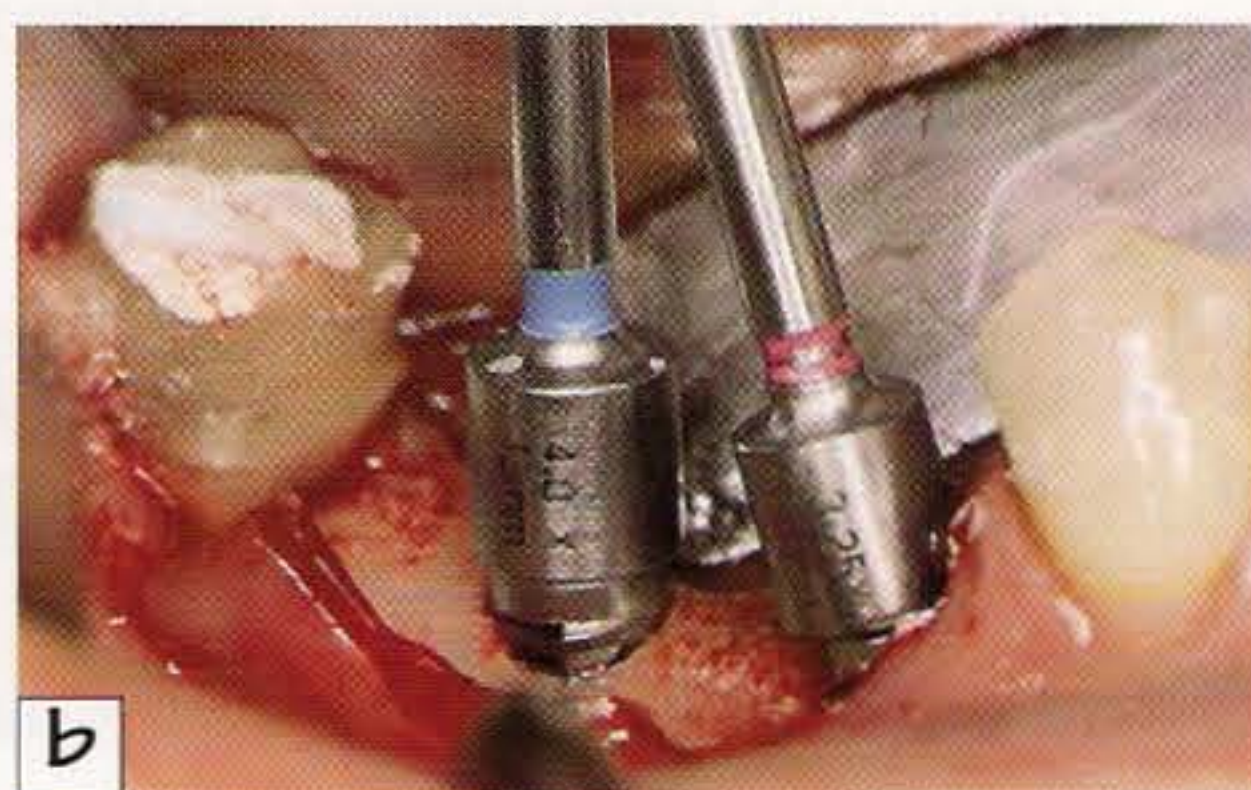


c

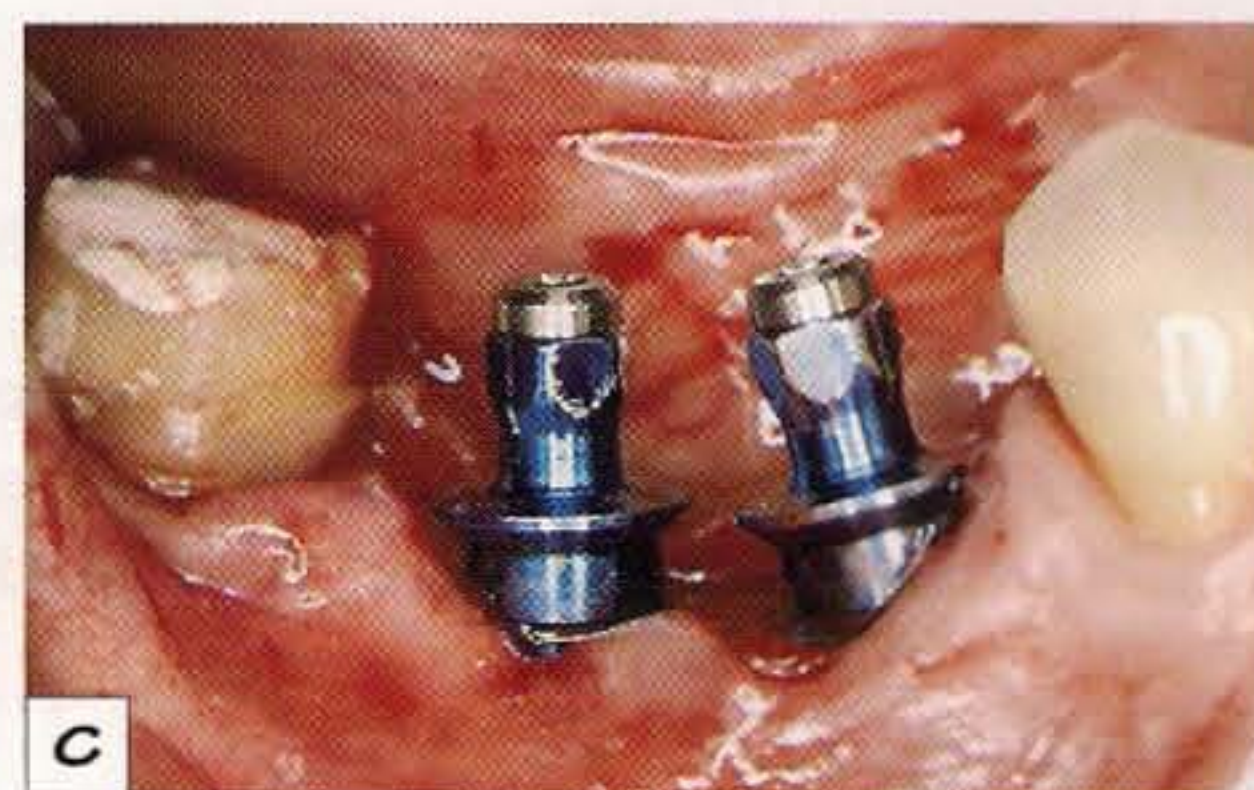
▲ **Fig 14-5** Presurgical clinical examination. (a) Periapical radiograph at the beginning of treatment. The image indicates that the bone height is adequate for implant placement. (b) Preoperative clinical view after removal of the prosthesis. Both the molar and premolar will have to be restored. (c) Oblique CT scan section of the edentulous site. The width and the height of the bone are sufficient for placement of two 13-mm implants.



a



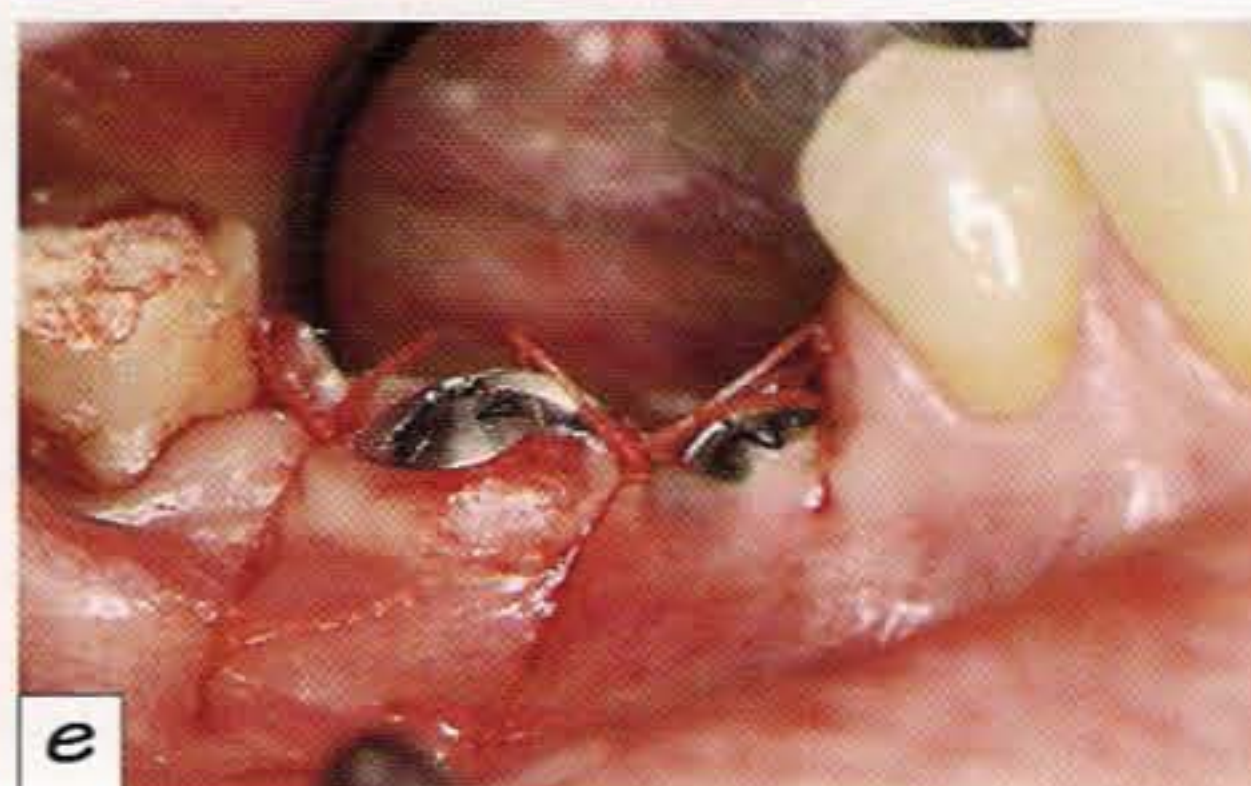
b



c



d



e



f

▲ **Fig 14-6** Surgical phase. (a) Extracted premolar. (b) Drilling in the healed and extraction sites. The axes of the drills are not parallel because the mesial implant is going to be oriented distal to the alveolus of the extracted tooth, to enhance primary stability. (c) Implants with the implant holder in position. Their long axes have different orientations. (d) Occlusal view of the implants. Both have been placed subcrestally to enhance primary stability. (e) Healing abutments in place. (f) Control radiograph. The diameter of the abutments is different to promote, from the beginning, a harmonious emergence profile.

Technical difficulty		Esthetic requirements	
Team coordination		Extra costs	
Treatment time		Risk assessment	
Number of implants		Documentation	

▲ **Fig 14-7** Key information for treatment option 1.

Transition from surgical treatment site to prosthetic treatment site. The transition from the surgical treatment site to the prosthetic treatment site should be planned in advance to avoid misunderstandings and ensure that the patient experiences a seamless transition from the surgical phase to the prosthetic phase.

Prosthetic phase: Treatment option 1

Screw-retained provisional prosthesis placed immediately after surgery; the hollowed prosthesis is prepared in the laboratory before surgery and the cylinders are prepared at chairside.

Reminder:

This option is chosen when a screw-retained prosthesis is preferred and when the principal determinant of treatment is the psychologic comfort of the patient. The patient does not want to go without a restoration, even briefly, after surgery. A provisional prosthesis is delivered immediately after surgery.

Key information for treatment option 1

Figure 14-7 summarizes the key aspects of the prosthetic treatment when option 1 is followed.

Technical difficulty is average

The technical difficulty is average because the procedure is conducted by the clinician at chairside and it requires full attention to each detail.

Team coordination is limited

The prosthetic phase follows immediately after completion of surgery or is briefly delayed for a second session. The laboratory does not take part after the surgery.

Treatment time is average

The surgical and prosthetic appointments are combined and can last from 2 to 3 hours, distributed into 1 to 1.5 hours allotted for the surgical intervention and 1 to 1.5 hours for the prosthetic phase.

Number of implants: 1 to 3

The number of implants depends on whether a single crown or a multiunit prosthesis is being placed.

Esthetic requirements are low or nonexistent

The esthetic requirements in the mandible are minimal and strict criteria for implant positioning do not have to be followed (see chapter 5). In the maxilla, the esthetic requirements may be high if the premolars are visible in the smile line; in this case, strict rules for 3D implant positioning need full compliance.

Extra costs are moderate

In the mandible, provisional restoration is seldom required by the patient; therefore, the extra costs associated with immediate loading are moderate.

In the maxillary premolar area, provisional restoration should be proposed, and thus the extra costs for immediate loading are lower. Component and laboratory costs are limited but the general fee is higher because of the time spent by the prosthodontist in preparing the prosthesis instead of having it fabricated in the laboratory.

Additional risk is high

Good primary stability should not be difficult to obtain in the mandible, but it may be more difficult to obtain in the maxilla. Although it is easy to take the prosthesis out of occlusion, any uncontrolled force may be considerable in intensity and damaging.

Documentation in the literature is scarce

Some studies about immediate loading in these segments have appeared in the literature, primarily with regard to the maxillary premolar region. Far fewer reports have been published on the premolar and molar segments of the mandible or the maxillary molar.

Sequence and timing of steps for treatment option I

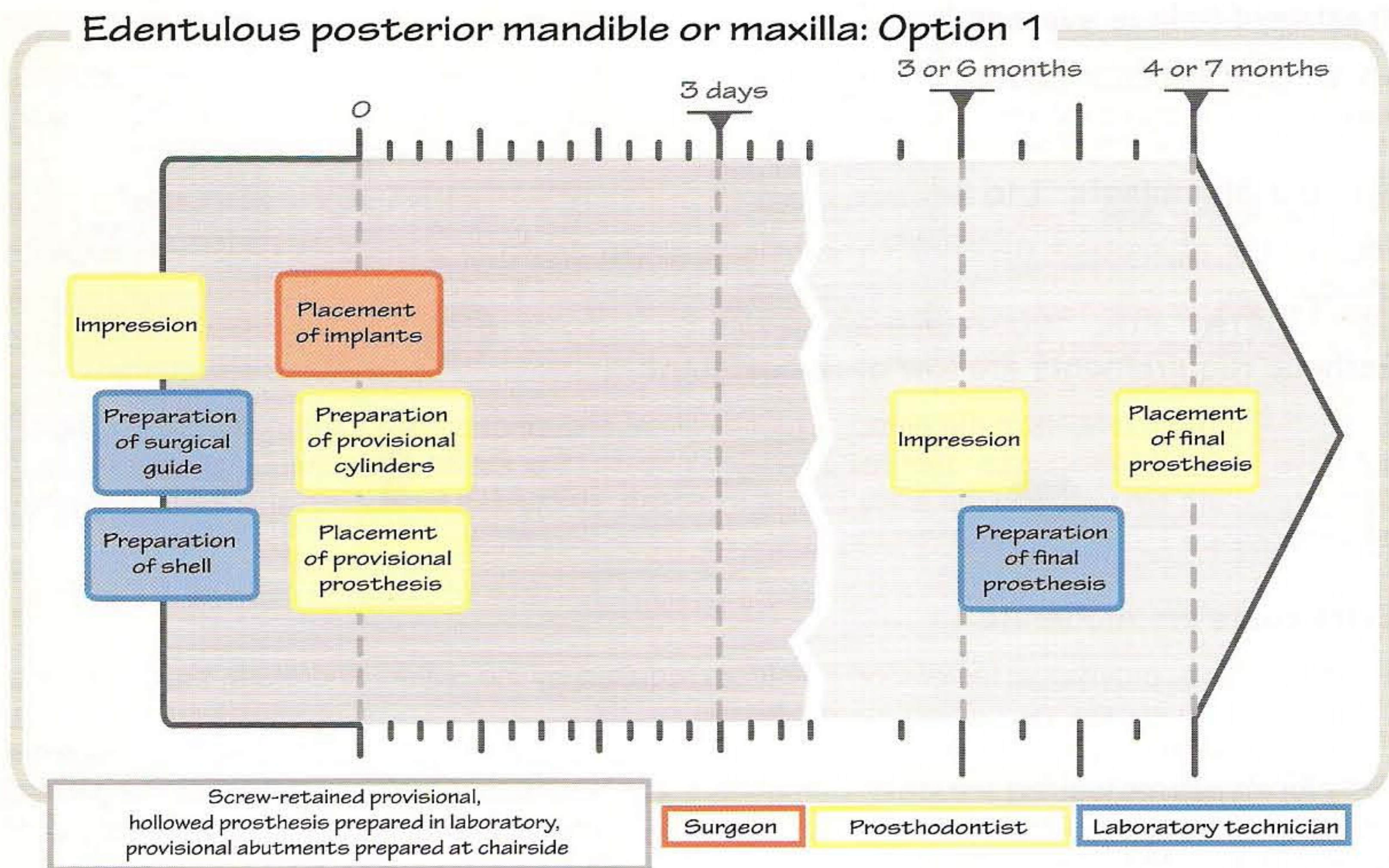
Figure 14-8 illustrates the chronology for treatment option 1:

- All the laboratory procedures are concluded before implant placement; the components fabricated include the surgical guide and the hollowed shell for the provisional prosthesis.
- The implants are placed in the usual way, with consideration for the rules of positioning.
- The prosthetic phase is undertaken immediately after completion of the surgical procedure or with a pause only long enough to allow the patient to make the transition from one site to another. The prosthesis is delivered within hours after surgery.
- After the provisional prosthesis has been functioning in the mouth for 2 months in the mandible or 6 months in the maxilla, a time that allows the maturation of the soft tissues, the prosthodontist verifies implant stability before beginning fabrication of the final prosthesis.
- After this point, construction of the final prosthesis can begin.

Checklist of materials required for treatment option I

Prosthetic components prepared in advance by the laboratory

- Surgical guide
- Hollowed acrylic resin shell



▲ **Fig 14-8** Sequence and timing of steps for treatment option 1. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Materials needed for the surgical and prosthetic phases

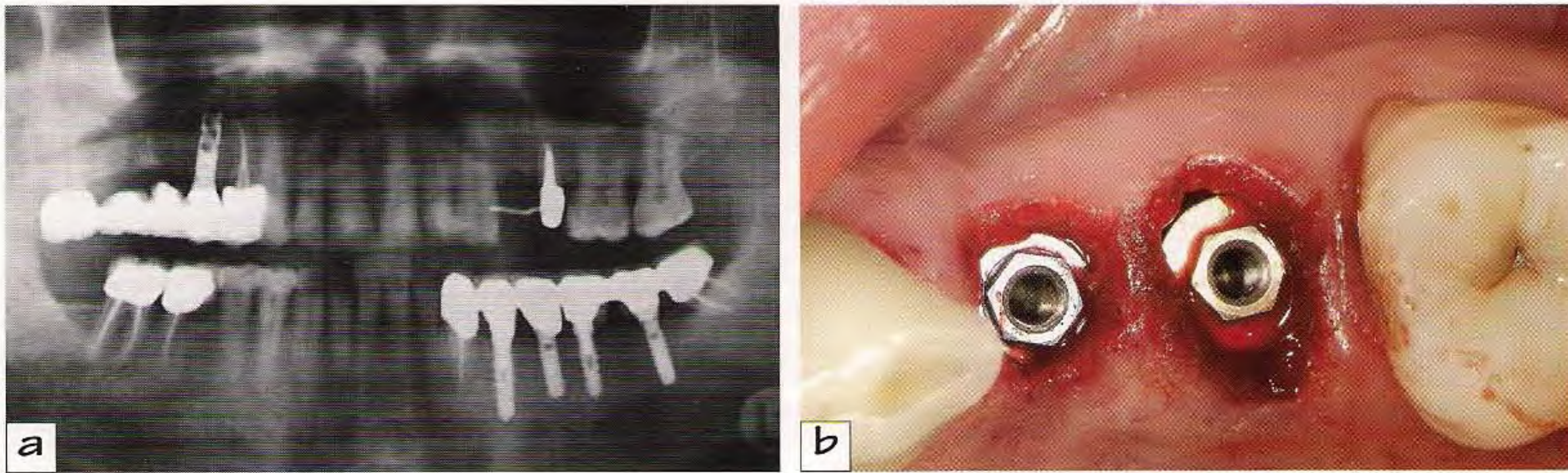
- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)

If provisional cylinders are used

- Provisional cylinders (prosthodontist)
- Disk for sectioning the cylinders (prosthodontist)
- Acrylic resin or resin composite for attachment of the hollowed shell to the cylinders and adjustment of the margins of the prosthesis (prosthodontist)
- Photopolymerizing lamp, if needed (prosthodontist)
- Try-in screws (prosthodontist)
- Gold screws (prosthodontist)

If provisional abutments are used

- Gingihue titanium abutments (Biomet 3i) (prosthodontist)
- Acrylic resin or resin composite (prosthodontist)
- Photopolymerizing lamp, if needed (prosthodontist)
- Burs for opening the hollowed shell (prosthodontist)
- Try-in screws (prosthodontist)
- Gold screws (prosthodontist)



▲ **Fig 14-9** Implant placement in a combination of healed and extraction sites. (a) Radiograph of the preoperative situation. The maxillary left second premolar supports a mesial extension. (b) Postoperative view. One implant has been placed in the healed site and another in the extraction site.

Immediate-loading protocol

Presurgical and surgical phases

The presurgical and surgical procedures are common to all prosthetic options. When these steps are concluded, the patient is provided with healing abutments and is ready for the prosthetic phase. A case will be presented to illustrate application of the prosthetic phase according to treatment option 1.

Case history

The root of a second premolar fractured, making extraction necessary. The adjacent first premolar was already missing (Fig 14-9a). The patient asked for the resultant space to be restored as rapidly as possible for professional reasons. The second premolar was extracted and two implants were placed, one in the healed site and the other in the extraction site (Fig 14-9b).

Provisional prosthetic phase

Preparation of provisional abutment at chairside and delivery of provisional prosthesis

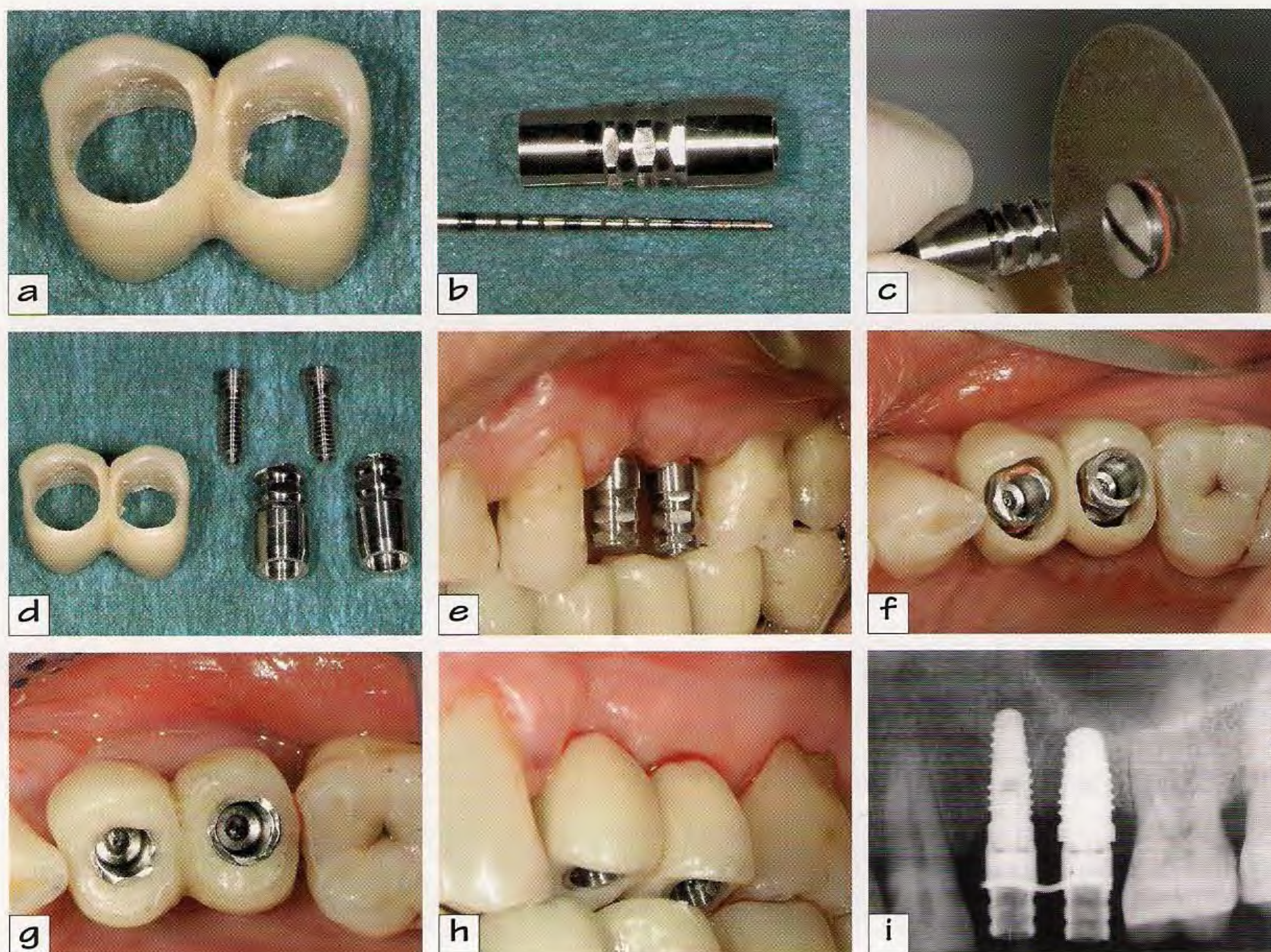
Before surgery, a hollowed shell of the prosthesis is prepared in the laboratory and provisional cylinders, which are trimmed to the proper height (Figs 14-10a to 14-10d). The prosthodontist places them in the mouth and further adjusts the height of the cylinders if necessary (Fig 14-10e). The shell is adapted to the abutments and bonded to the cylinders with small amounts of acrylic resin (Fig 14-10f). The prosthodontist then removes the prosthesis and fills any gaps with acrylic resin before replacing the prosthesis in the mouth (Fig 14-10g). After dynamic evaluation of the occlusion, the prosthodontist takes the prosthesis out of occlusion (Fig 14-10h).

Control radiograph

At the end of the prosthetic phase, a radiograph is taken (Fig 14-10i); the image will serve as a baseline reference to evaluate changes in bone status over time.

Follow-up

After this provisional prosthesis was functioning for 6 months, it was removed. The condition of the soft tissues was found to be satisfactory (Fig 14-11a). Impression copings were placed (Fig 14-10b), and an impression was taken and sent to the laboratory. The laboratory fabricated the abutments on which the final prosthesis was cemented (Figs 14-11c and 14-11d). A radiograph taken after cementation of the final prosthesis revealed the status of the hard tissues (Fig 14-11e).



▲ **Fig 14-10** Preparation and placement of a provisional screw-retained prosthesis. (a) Hollowed shell prepared by the laboratory before surgery. (b) Provisional cylinders used for preparation of the screw-retained prosthesis. (c) Preparation of cylinder with a disk. (d) Prosthetic components ready for placement of the restoration. (e) Try-in of the abutments. (f) Shell adapted to the abutments. (g) Gaps filled with acrylic resin. (h) Prosthesis out of occlusion. (i) Control radiograph. (Surgery and prosthesis by Dr T. Testori.)

Prosthetic phase: Treatment option 2

Screw-retained provisional prosthesis placed within 24 to 48 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

Reminder:

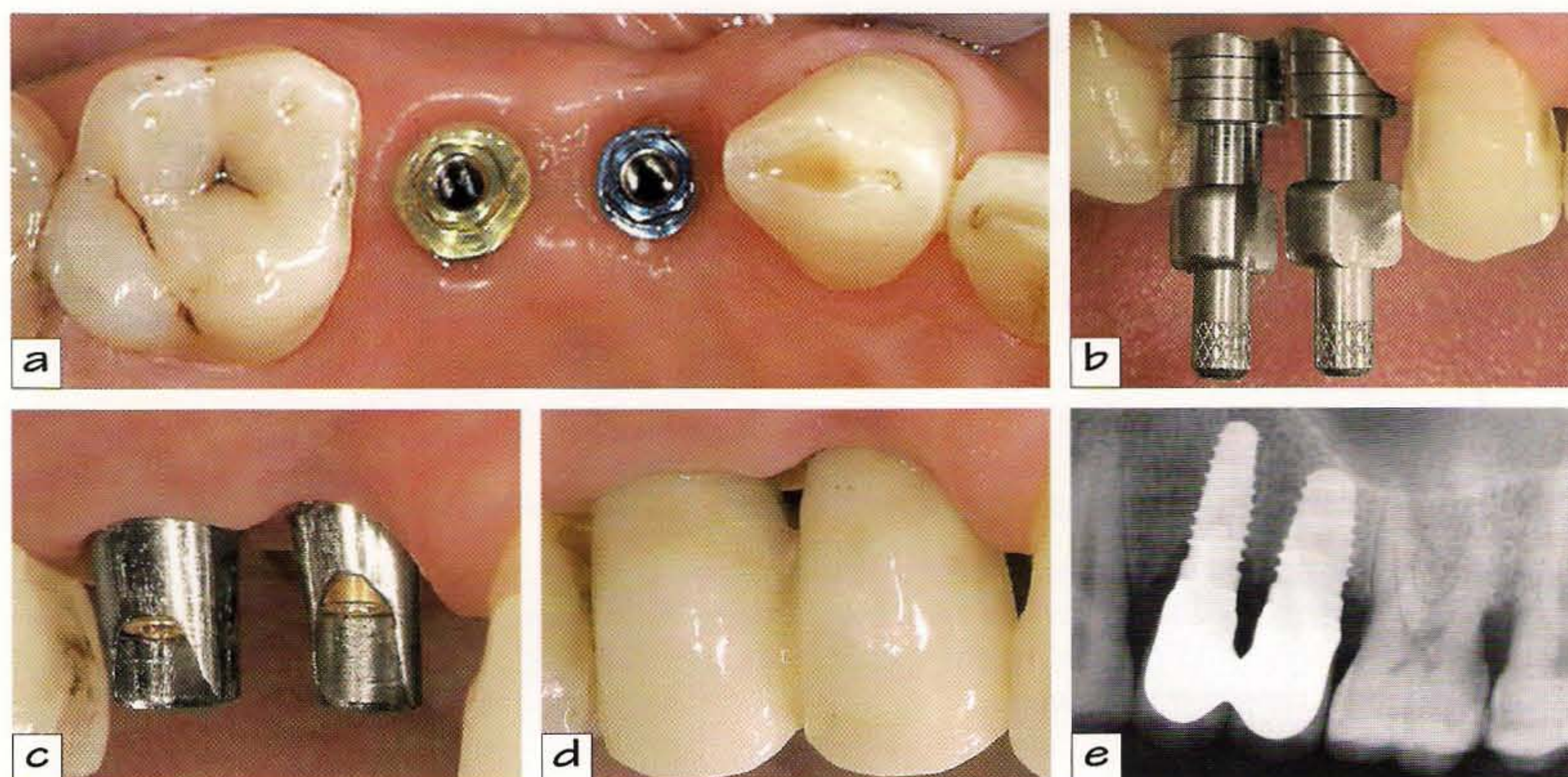
This option is selected when a screw-retained prosthesis is preferred and when the principal determinant of treatment is the physical comfort of the patient. The patient is not willing or able to endure a protracted combined surgical and prosthetic session that could demand 2 to 3 hours of uninterrupted time in the dental chair. The procedure is divided into two appointments of reasonable duration in 1 day or 2 consecutive days.

Key information for treatment option 2

Figure 14-12 summarizes the key aspects of the treatment option 2.

Technical difficulty is low

The screw access holes must emerge on the occlusal surface of the prosthesis. The prosthetic phase is greatly simplified because the prosthesis is made in the laboratory.



▲ **Fig 14-11** Final prosthetic phase. (a) Condition of the soft tissues after removal of the provisional screw-retained prosthesis. (b) Impression copings screwed in place for the final prosthesis. (c) Try-in of the final prosthetic abutments. (d) Placement of the final prosthesis in the mouth. (e) Control radiograph taken at placement of the final prosthesis, 6 months after placement of the provisional prosthesis. The condition of the hard tissues has changed very little from their postoperative status (see Fig 14-10e). (Prosthesis by Dr T. Testori.)

Technical difficulty		Esthetic requirements	
Team coordination		Extra costs	
Treatment time		Risk assessment	
Number of Implants		Documentation	

▲ **Fig 14-12** Key information for treatment option 2.

Team coordination is moderate

The prosthetic phase does not follow surgery in a single session. However, it begins immediately after implant placement when the prosthodontist takes an impression that is sent to the laboratory. The laboratory starts working immediately, but there is no urgency because there are no critical esthetic or functional demands to satisfy. A prosthesis of only a few units can be easily fabricated within 72 hours. However, the required level of team coordination increases when the maxillary premolar area is treated, because esthetics requirements prevail and the prosthesis should be delivered as soon as possible.

Treatment time is limited

The surgical and the prosthetic phases are not immediately consecutive. Total treatment requires 1 to 1.5 hours for the surgical phase, depending on how many implants are placed, and 45 minutes to 1 hour for the prosthetic phase. The prosthetic phase itself is divided into two sessions, one for impression procedures and one for delivery of the prosthesis.

Number of implants: 1 to 3

The number of implants needed depends on whether a single crown or a multiunit prosthesis is being made.

Esthetic requirements are low or nonexistent

Careful attention to esthetic considerations in the mandible is not necessary, and strict criteria for 3D implant positioning do not have to be followed (see chapter 5). In the maxilla, esthetic requirements may be high if the premolars are visible in the smile line; in this case, the rules for implant positioning must be strictly followed.

Extra costs are moderate

In the mandible, provisional restoration is seldom required by the patient and the extra costs associated with immediate loading are moderate.

In the maxillary premolar area, provisional restoration should be proposed, and thus the extra costs for immediate loading are low. Component and laboratory costs are limited.

Additional risk is high

Good primary stability should not be difficult to achieve in the mandible, but it may be more difficult to obtain in the maxilla. Although it is easy to take the prosthesis out of occlusion, any uncontrolled force may be considerable in intensity and damaging.

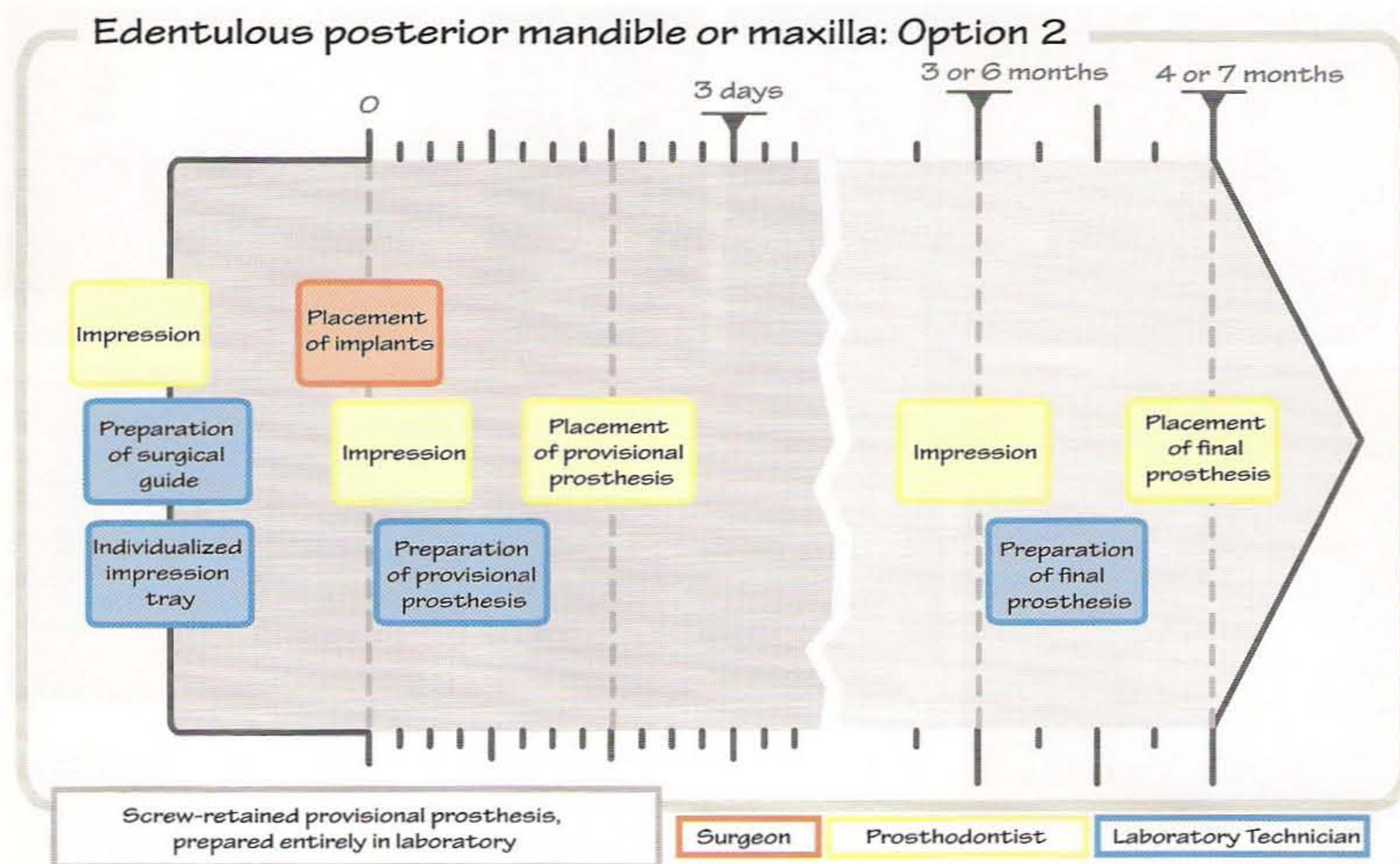
Documentation in the literature is scarce

Some studies about application of the immediate-loading protocol to these segments have appeared in the literature, primarily with regard to the maxillary premolar region. Far fewer studies have been published on immediate loading in the premolar and molar segments of the mandible or the maxillary molar.

Sequence and timing of steps for treatment option 2

Figure 14-13 illustrates the chronology for treatment option 2.

- The laboratory proceeds in two stages. Before implant placement, the laboratory makes the surgical guide and the individualized impression tray. Afterward, the laboratory fabricates the prosthesis.
- Implants are placed according to the established rules for the procedure.
- The prosthodontist takes an impression immediately after completion of the surgical procedure.
- The prosthetic phase itself begins in the next session, which takes place within the next 72 hours, depending on the availability of the laboratory and the patient's request.
- After the provisional prosthesis has been functioning in the mouth for 2 months in the mandible or 6 months in the maxilla, a time that allows the maturation of the soft tissues, the prosthodontist verifies implant stability before beginning fabrication of the final prosthesis.
- After this point, construction of the final prosthesis can begin.



▲ **Fig 14-13** Sequence and timing of steps for treatment option 2. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Checklist of materials required for treatment option 2

Prosthetic components prepared in advance by the laboratory

- Surgical guide
- Individualized impression tray

Materials needed for the surgical and prosthetic phases

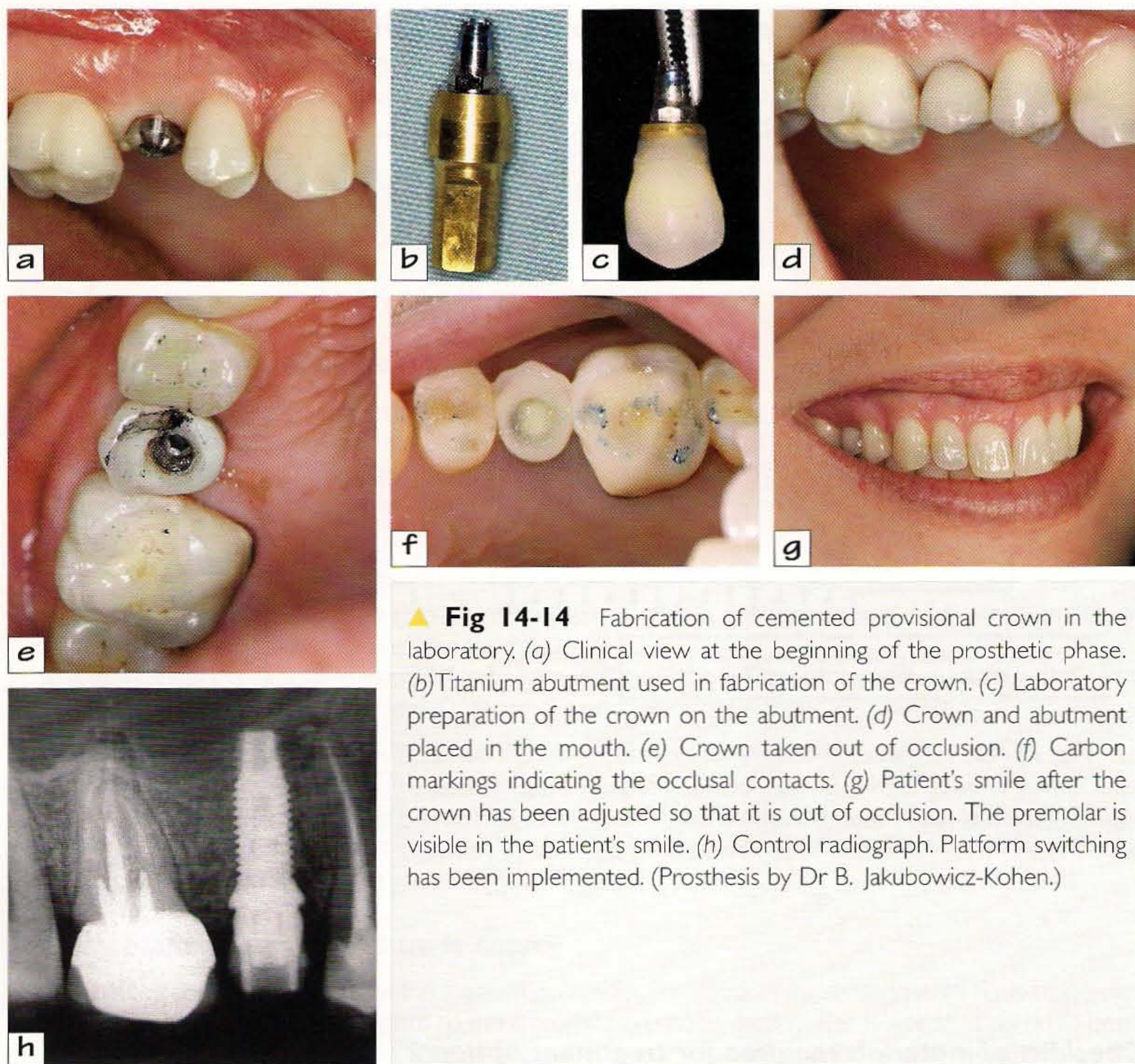
- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Components needed for a pick-up impression with the appropriate number of impression copings (prosthodontist)
- Implant analogs (laboratory)
- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)

If provisional cylinders are used

- Provisional cylinders (laboratory)

If provisional abutments are used

- Titanium abutments (laboratory)



Immediate-loading protocol

Presurgical and surgical phases

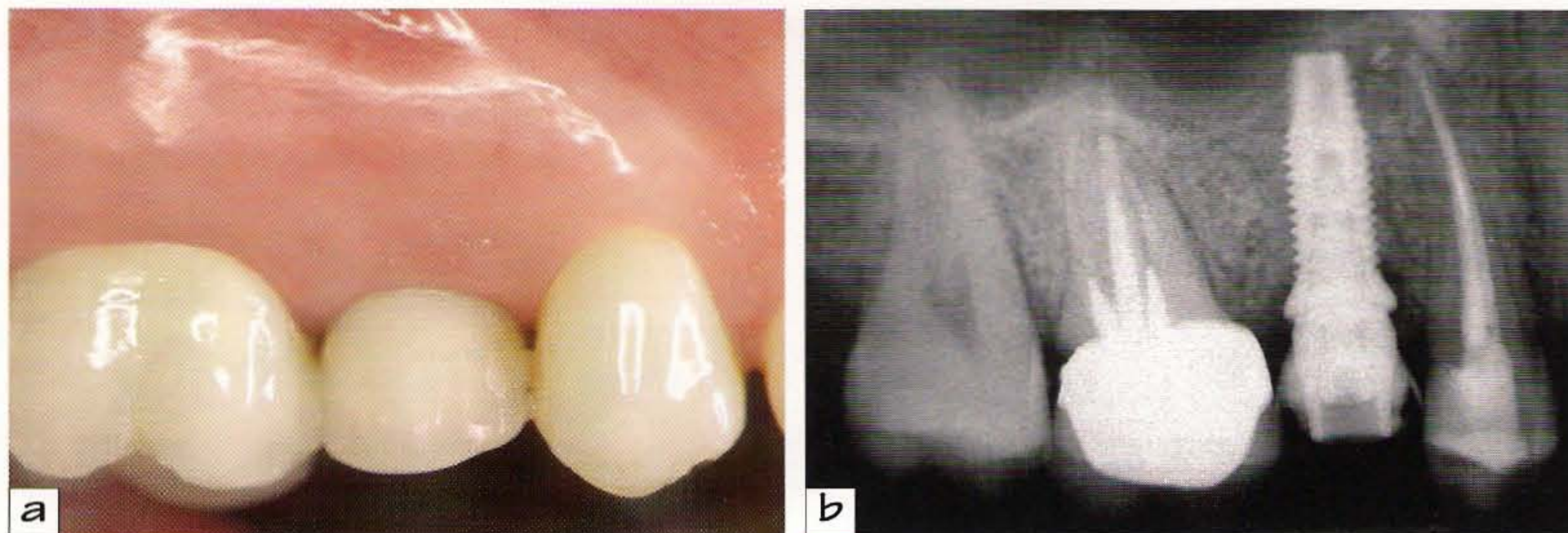
The presurgical and surgical procedures, discussed earlier in the chapter, are the same for all options. When those procedures are concluded, the patient is provided with healing abutments and is ready for the prosthetic phase. A case will be presented to illustrate the prosthetic phase according to option 2.

Provisional prosthetic phase

Immediately after surgery, the patient arrives at the prosthetic treatment site with a healing abutment in place to begin the next phase of treatment (Fig 14-14a).

Impression

The prosthodontist removes the healing abutment from the implant neck and places the impression coping. A control radiograph is taken if the implant has an external hex. The prosthodontist takes an impression as well as a wax bite registration of the interocclusal relationship and sends them to the laboratory.



▲ **Fig 14-15** Follow-up at 3 months. (a) Buccal view of the crown left out of occlusion. (b) Control radiograph. The bone resorption reaches the first thread, indicating that the platform-switching protocol did not effectively maintain the crestal bone. (Prosthesis by Dr B. Jakubowicz-Kohen.)

Laboratory procedures

The laboratory pours the casts with the implant analog in place; an acrylic resin crown is fabricated around the provisional cylinders, leaving it in occlusion. Later, the prosthodontist will take the restoration out of occlusion in the mouth.

In this case, a Gingihue titanium abutment was used to support the screw-retained restoration (Fig 14-14b). The laboratory shapes the abutment with the milling machine and attaches it to the crown. An opening is left for the screw to attach the crown to the implant. The technician returns the assembly to the prosthodontist (Fig 14-14c).

Delivery of prosthesis at chairside

Within 72 hours, the prosthodontist screws the prosthesis in the implant neck with a 20-Ncm torque (Fig 14-14d). The crown is taken out of occlusion in resting position and excursive movements (Figs 14-14e and 14-14f). For this patient, the fixed premolar crown is included in the smile line (Fig 14-14g).

Control radiograph

After the crown is attached, a periapical radiograph is taken (Fig 14-14h); the radiograph will serve as a baseline reference for future appointments.

Follow-up

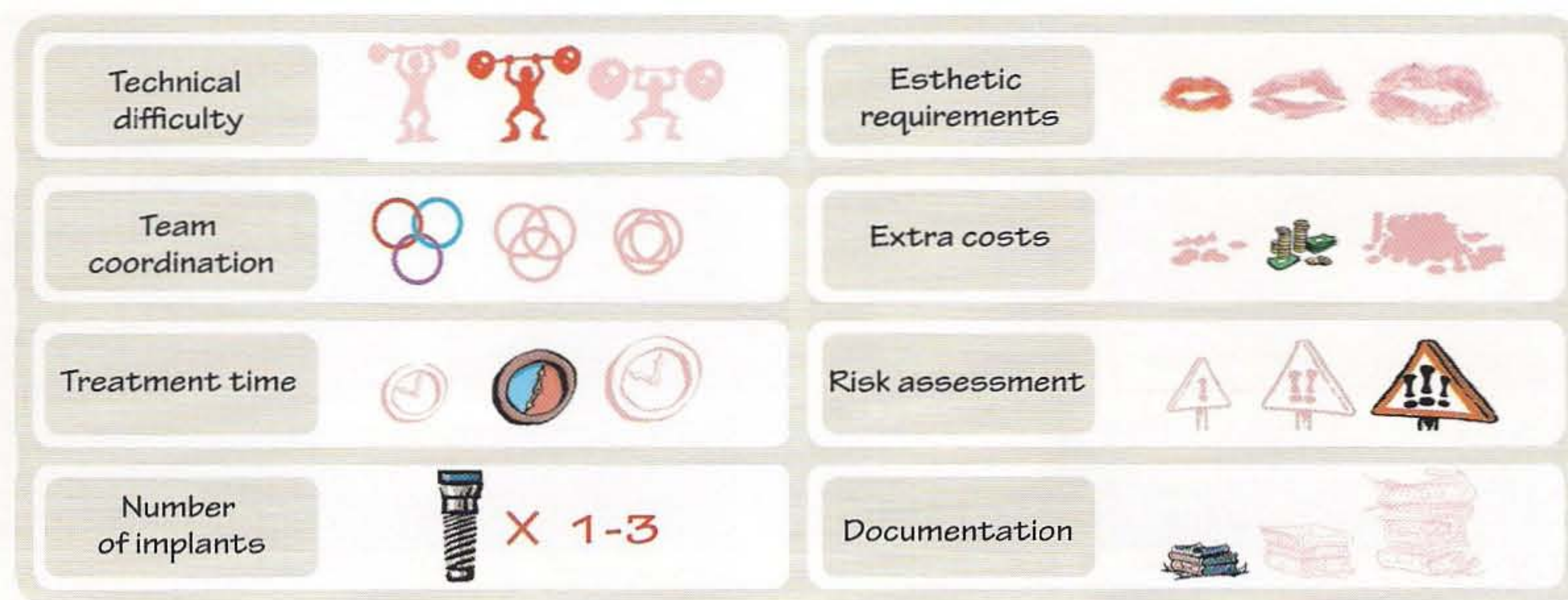
Clinical and radiographic assessment of the crown at 3 months revealed that platform switching was not effective in retaining the height of the crestal bone (Fig 14-15). Bone resorption reached the first thread.

Prosthetic phase: Treatment option 3

Cemented provisional prosthesis placed immediately after surgery; the hollowed prosthesis is prepared by the laboratory before surgery and the abutments are prepared at chairside.

Reminder:

This option is chosen when a cemented prosthesis is preferred and when the principal determinant of treatment is the psychologic comfort of the patient. The patient does not want to be deprived of a restoration even briefly. The clinician delivers the prosthesis immediately after surgery.



▲ **Fig 14-16** Key information for treatment option 3.

Key information for treatment option 3

Figure 14-16 summarizes key aspects of treatment option 3.

Technical difficulty is average

The technical difficulty is average because the procedure is conducted by the clinician at chairside and it requires full attention to each detail.

Team coordination is limited

The prosthetic phase follows immediately after completion of surgery or is briefly delayed for a second session. The laboratory does not participate after the surgery.

Treatment time is average

The surgical and prosthetic appointments are combined and can last from 2 to 3 hours. They are distributed into 1 to 1.5 hours allotted to the surgical intervention and 45 minutes to 1 hour for the prosthetic phase.

Number of implants: 1 to 3

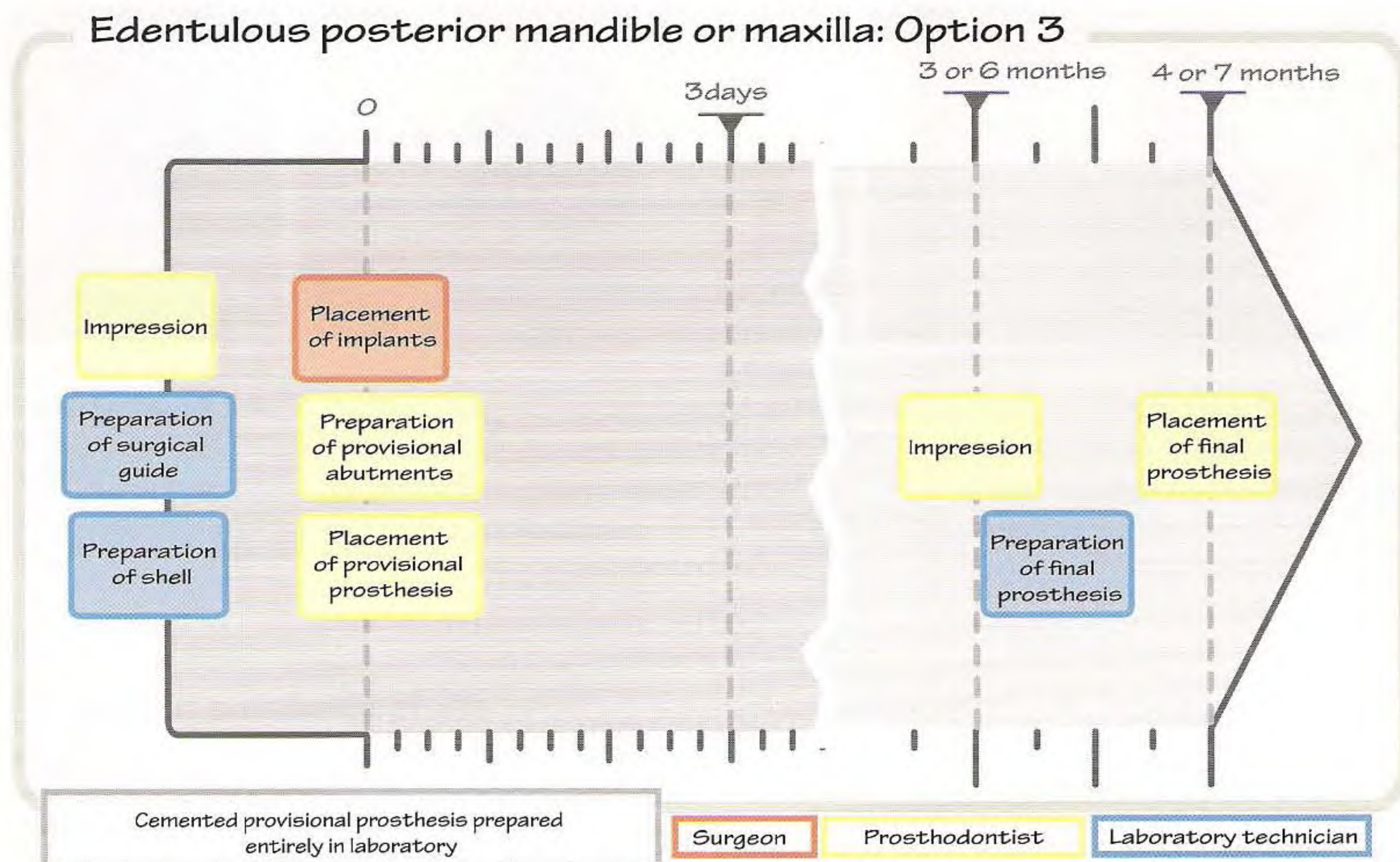
The number of implants depends on whether a single crown or a multiunit prosthesis is being placed.

Esthetic requirements are low or nonexistent

In the mandible, the need for careful attention to esthetic considerations is not elevated, and strict criteria for implant positioning do not have to be followed (see chapter 5). In the maxilla, esthetic requirements may be high if the smile line reveals the premolars; in this case, strict rules for implant positioning must be strictly followed.

Extra costs are moderate

In the mandible, provisional restoration is seldom required by the patient and the extra costs associated with immediate loading are moderate. In the maxillary premolar area, provisional restoration should be proposed, and thus the extra costs for immediate loading are lower. Component and laboratory costs are limited, but the general fee is high because of the time spent by the prosthodontist in preparing the prosthesis instead of having it fabricated in the laboratory.



▲ Fig 14-17 Sequence and timing of steps for treatment option 3. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Additional risk is high

Good primary stability should not be difficult to obtain in the mandible, but it may be more difficult to obtain in the maxilla. Although it is easy to take the prosthesis out of occlusion, any uncontrolled force may be considerable in intensity and damaging.

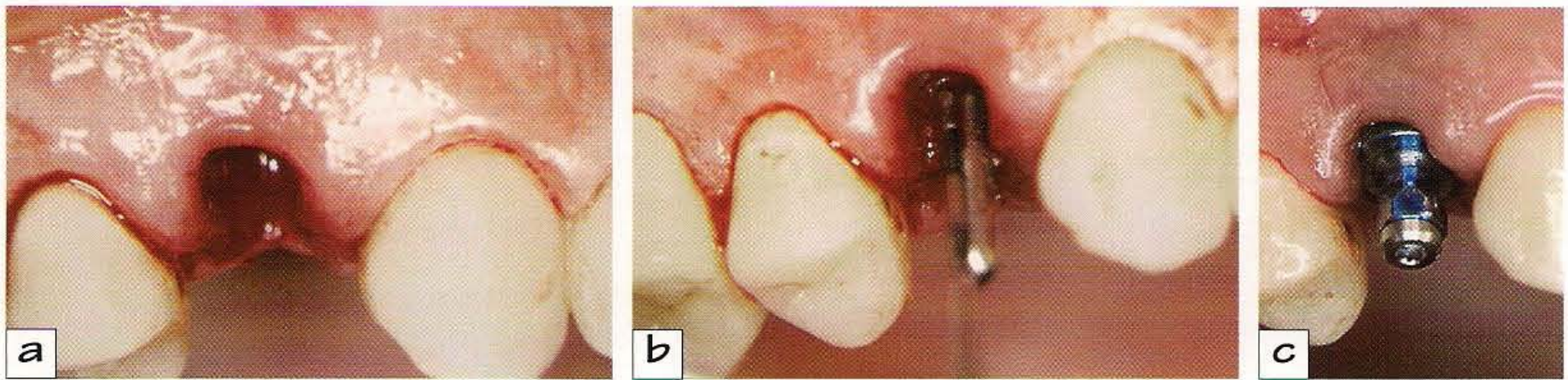
Documentation in the literature is scarce

Some studies about application of the immediate-loading protocol to these segments have appeared in the literature, primarily with regard to the maxillary premolar region. Far fewer studies have been published on the premolar and molar segments of the mandible or the maxillary molar.

Sequence and timing of steps for treatment option 3

Figure 14-17 illustrates the chronology of treatment carried out according to option 3.

- All the laboratory procedures are concluded before implant placement, including fabrication of the surgical guide and the hollowed shell for the provisional prosthesis.
- The implants are positioned in the usual way, with consideration for the rules for 3D positioning.
- The prosthetic phase is undertaken immediately after completion of the surgical procedure or with a pause only long enough to allow the patient to make the transition from one site to another. The prosthesis is delivered within hours after surgery.
- After the provisional prosthesis has been functioning in the mouth for 2 months in the mandible or 6 months in the maxilla, a time that allows maturation of the soft tissues, the prosthodontist verifies implant stability before beginning fabrication of the final prosthesis.
- After this point, construction of the final prosthesis can begin.



▲ **Fig 14-18** Extraction of a maxillary right first premolar and implant placement in the extraction site. (a) Clinical view after the extraction. (b) Assessment of the long axis of the implant. The implant was placed in a flapless procedure. (c) Implant in position with its implant carrier after seating.

Checklist of materials required for treatment option 3

Prosthetic components prepared in advance by the laboratory

- Surgical guide
- Hollowed acrylic resin shell

Materials needed for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Titanium abutments (prosthodontist)
- Burs for preparation the titanium abutments (prosthodontist)
- Acrylic resin or resin composite for attachment of the hollowed shell to the cylinders and adjustment of the margins of the denture (prosthodontist)
- Photopolymerizing lamp, if needed (prosthodontist)
- Try-in screws (prosthodontist)
- Gold screws (prosthodontist)
- Temporary cement (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

The presurgical and surgical procedures, as discussed earlier, are the same for all prosthetic treatment options. When these procedures are concluded, the patient is provided with healing abutments and is ready for the prosthetic phase. The following case will be used to illustrate prosthetic treatment option 3.

Case history

Because the root had fractured, a maxillary right first premolar had to be extracted. For reasons associated with her busy schedule, the patient asked that the missing tooth be replaced as quickly as possible. After the tooth was removed (Fig 14-18a), a conical 4 × 13-mm Osseotite NT implant was placed in the extraction site (Figs 14-18b and 14-18c).



▲ **Fig 14-19** Fabrication of a cemented provisional restoration at chairside. (a) Prosthetic components prepared in advance for fabrication of a crown at chairside. (b) Provisional crown in place. (c) Assessment of the crown in centric occlusion. Because this tooth is visible when the patient smiles, its immediate rehabilitation greatly comforted this patient. (Prosthesis by Dr C. Raygot and G. Fournier.)

Provisional prosthetic phase

After surgery, the patient arrived at the prosthetic treatment site with a healing abutment in place.

Preparation of provisional abutment at chairside and delivery of provisional prosthesis

The prosthodontist prepared a titanium Gingihue abutment at chairside and adapted the hollowed shell made before surgery (Fig 14-19a). After unscrewing the healing abutment, the prosthodontist placed the titanium abutment in the patient's mouth to verify the implant axis. The abutment was then properly shaped, and the shell was filled with acrylic resin to fit over the abutment. The abutment was screwed in the implant with 20 Ncm of torque and the crown was cemented in place with temporary cement (Fig 14-19b). All excess cement was meticulously removed, and the crown was taken out of occlusion (Fig 14-19c).

Just a few hours after surgery, this patient was able to leave the office with the tooth replaced, confident that her smile would not be disfigured by an unsightly space.

Control radiograph

A radiograph was taken as a baseline reference to allow evaluation of the response of the hard tissues to the new implant over time.

Prosthetic phase:

Treatment option 4

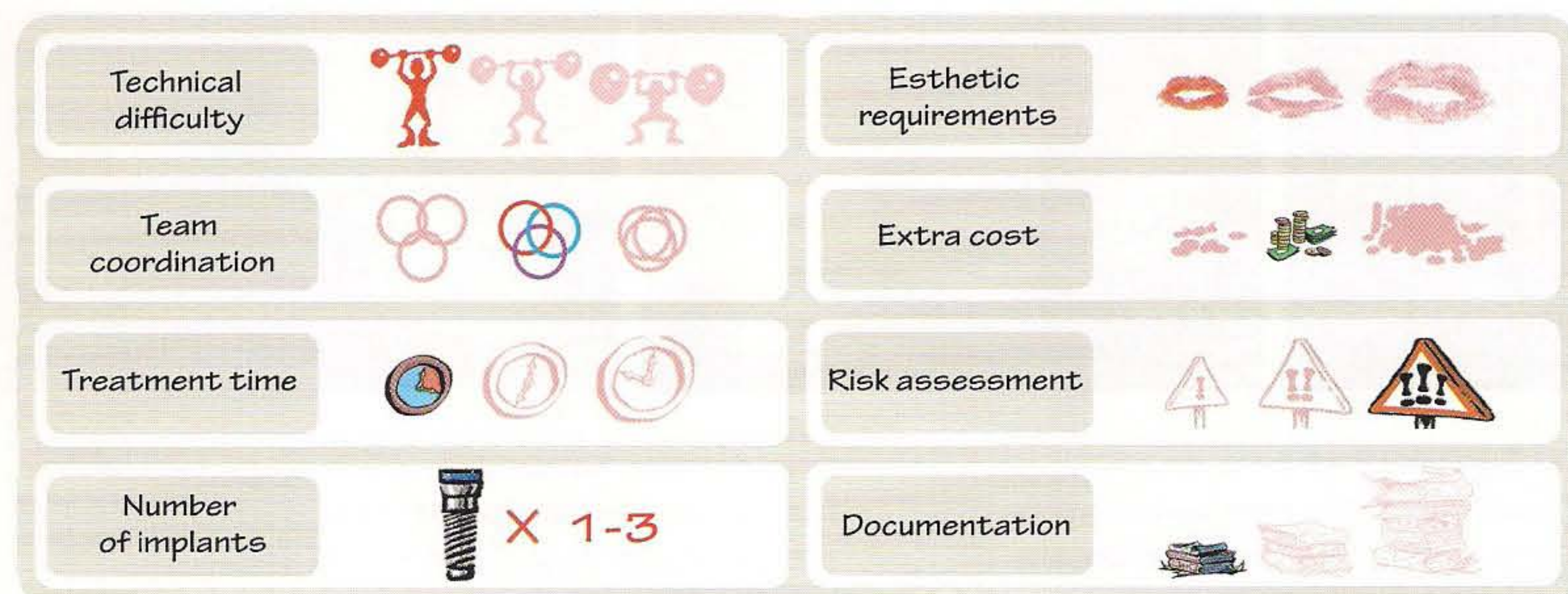
Cemented provisional prosthesis placed within 24 to 48 hours after surgery; the prosthesis is fabricated entirely in the laboratory.

Reminder:

This option is selected when a cemented prosthesis is preferred and when the principal determinant of treatment is the physical comfort of the patient. The patient is not willing or able to endure a protracted combined surgical and prosthetic session that could demand 2 to 3 hours of uninterrupted time in the dental chair. The procedure is separated into two appointments of reasonable duration in 1 day or in 2 consecutive days.

Key information for treatment option 4

Figure 14-20 summarizes the key aspects of treatment option 4.



▲ **Fig 14-20** Key information for treatment option 4.

Technical difficulty is low

The prosthetic phase is greatly simplified because the prosthesis is made in the laboratory.

Team coordination is moderate

The prosthetic phase does not follow surgery in a single session. It begins immediately after implant placement when the prosthodontist takes an impression that is sent to the laboratory. The laboratory starts working immediately, but there is no urgency because there are no critical esthetic or functional demands to satisfy. A prosthesis of only a few units can be easily fabricated within 72 hours. However, the necessary level of team coordination increases greatly when the maxillary premolar area is treated because esthetic conditions prevail, and the prosthesis should be delivered as soon as possible.

Treatment time is limited

The surgical and the prosthetic phases are not immediately consecutive. They consist of stages of 1 to 1.5 hours for the surgical phase, depending on how many implants are placed, and 45 minutes to 1 hour for the prosthetic phase. The latter phase is divided into two sessions, one for impression procedures and one for delivery of the prosthesis.

Number of implants: 1 to 3

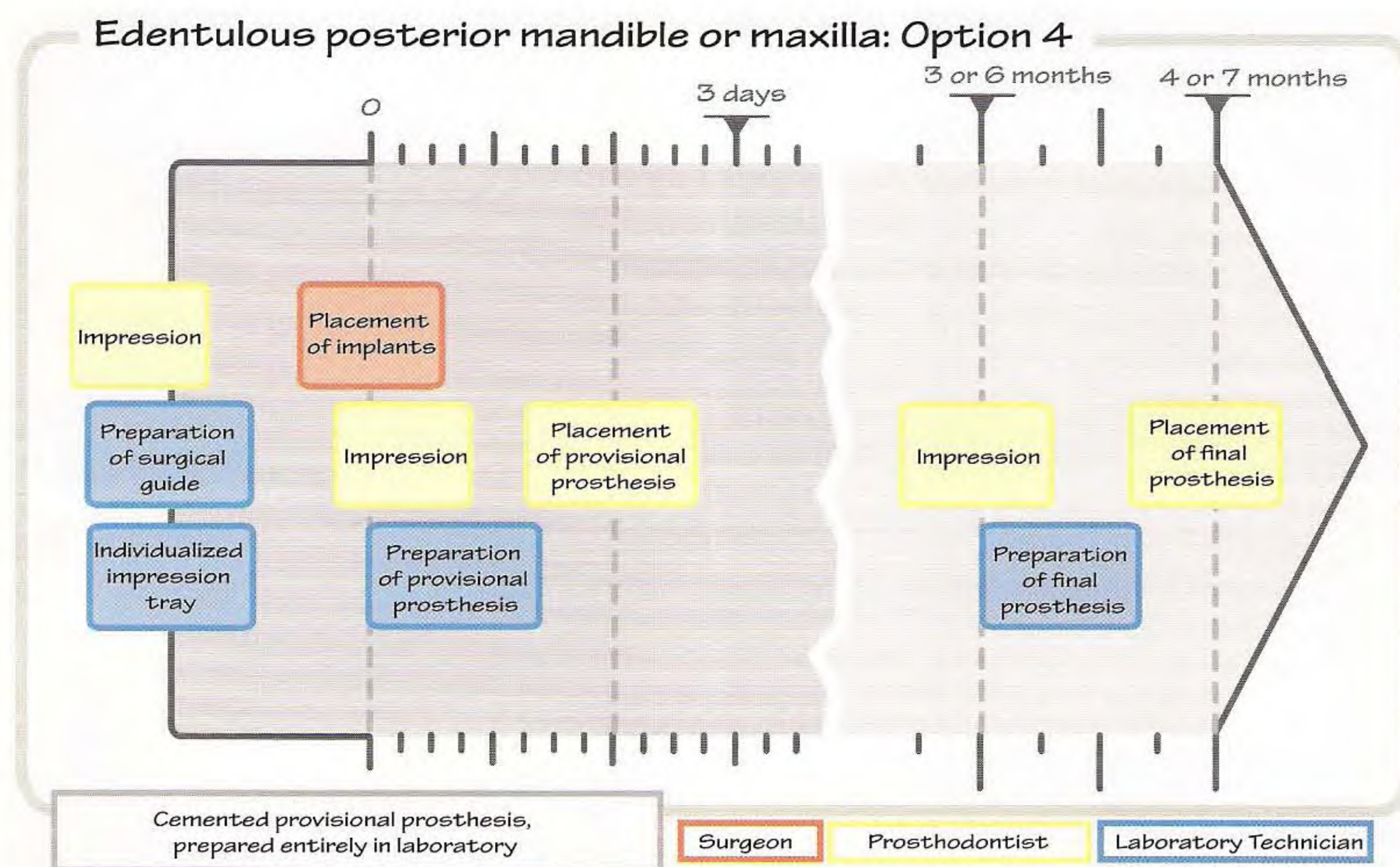
The number of implants needed depends on whether a single crown or a multiunit prosthesis is being made.

Esthetic requirements are low or nonexistent

Careful attention to esthetic considerations is not necessary in the mandible, and the criteria for 3D implant positioning do not have to be strictly followed (see chapter 5). In the maxilla, these requirements may be high if the premolars are visible when the patient smiles; in this case, the rules for 3D implant positioning must be carefully followed.

Extra costs are moderate

In the mandible, provisional restoration is seldom required by the patient, and the extra costs are moderate. In the premolar area of the maxilla, provisional restoration should usually be proposed; therefore, extra costs for immediate loading are low. Component and laboratory costs are limited.



▲ Fig 14-21 Sequence and timing of steps for treatment option 4. A different color is used to identify the interventions of each team member: surgeon or surgical phase (red); prosthodontist or prosthetic phase (yellow); and laboratory technician (blue).

Additional risk is high

Good primary stability should not be difficult to obtain in the mandible, but it may be more difficult to obtain in the maxilla. Although it is easy to take the prosthesis out of occlusion, any uncontrolled force may be considerable in intensity and damaging.

Documentation in the literature is scarce

Some studies on application of immediate loading in these segments have appeared in the literature, primarily with regard to the maxillary premolar region. Far fewer have been published about the premolar and molar segments of the mandible or the maxillary molar.

Sequence and timing of steps for treatment option 4

Figure 14-21 illustrates the chronology for treatment option 4.

- The laboratory proceeds in two stages. Before implant placement, the laboratory fabricates the surgical guide and the individualized impression tray. Afterward, the laboratory fabricates the prosthesis.
- Implants are placed according to the established rules for the procedure.
- The prosthodontist takes an impression immediately after completion of the surgical procedure.
- The prosthetic phase itself begins in the next session, which takes place within the next 72 hours, depending on the availability of the laboratory and on the patient's request.
- After the provisional prosthesis has been functioning in the mouth for 2 months in the mandible or 6 months in the maxilla, a time that allows maturation of the soft tissues, the prosthodontist verifies implant stability before beginning fabrication of the final prosthesis.
- After this point, construction of the final prosthesis can begin.

Checklist of materials required for treatment option 4

Prosthetic components prepared in advance by the laboratory

- Surgical guide
- Individualized impression tray

Materials needed for the surgical and prosthetic phases

- Implants designated for the procedure as well as longer and wider implants in reserve in case the bone type encountered requires them (surgeon)
- Healing abutments (surgeon)
- Screwdriver for the healing abutments (surgeon and prosthodontist)
- Components needed for a pick-up impression, including the appropriate number of impression copings (prosthodontist)
- Implant analogs (laboratory)
- Try-in screws (prosthodontist and laboratory)
- Gold screws (prosthodontist)
- Temporary cement (prosthodontist)

Immediate-loading protocol

Presurgical and surgical phases

The presurgical and surgical procedures are the same for all prosthetic treatment options. When these phases are concluded, the patient is provided with healing abutments and is ready for the prosthetic phase. The following case will illustrate the prosthetic phase of treatment option 4.

Case history

This case was used to illustrate the placement of implants in a combination of healed and extraction sites (see Figs 14-5 and 14-6).

Provisional prosthetic phase

Immediately after surgery, the patient arrives at the prosthetic treatment site with healing abutments in place (Fig 14-22a).

Impression

The prosthodontist removes the healing abutment from the implant necks and places the impression coping. A control radiograph is taken because of the external connection (Fig 14-22b).

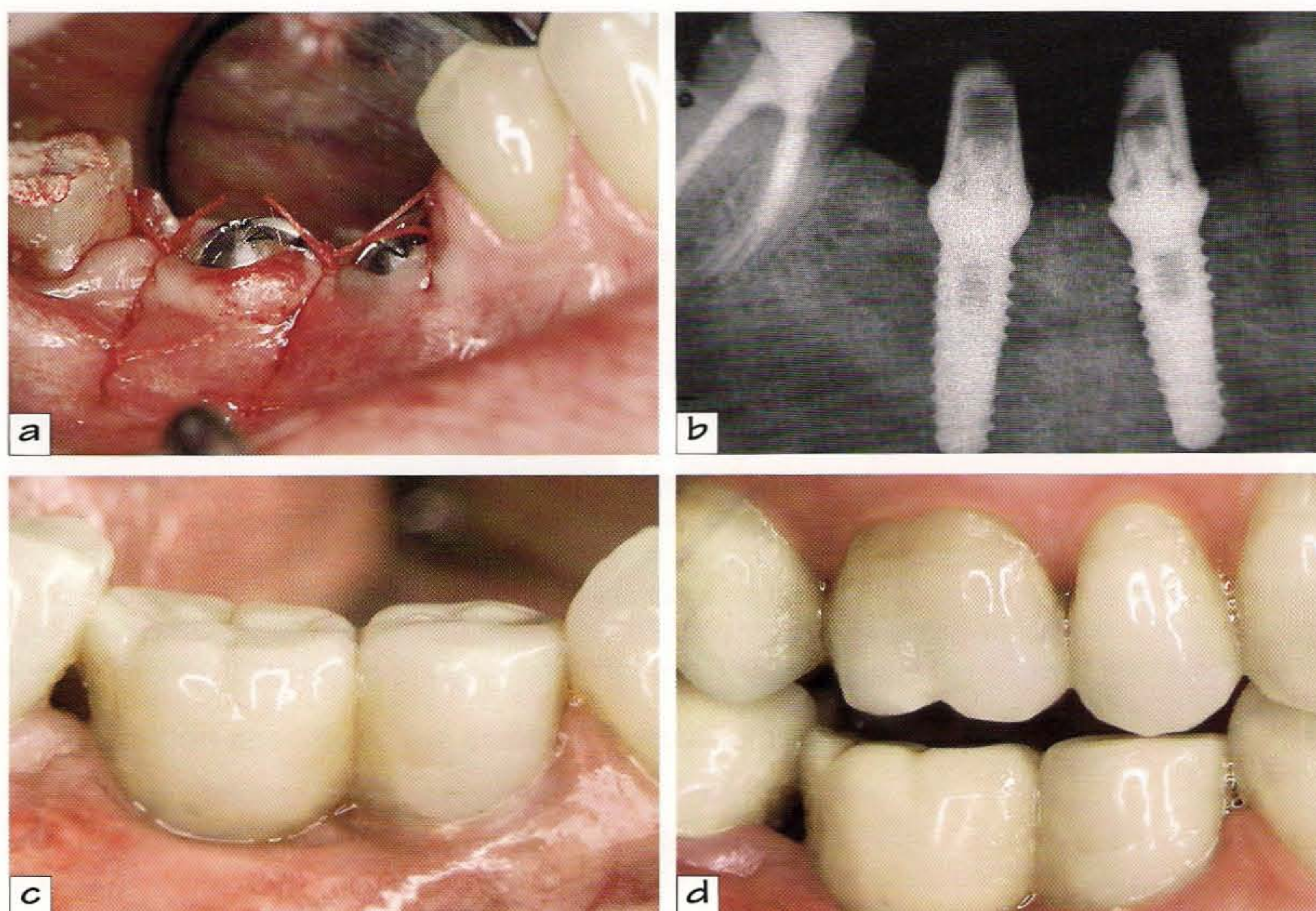
Adhesive tape is placed over the impression tray to prevent extrusion of the impression material. After the impression polymerizes, the tape is removed and the heads of the screws are located. The impression and a wax bite registration of the interocclusal relationship are sent to the laboratory for preparation of an acrylic resin prosthesis that will be cemented.

Laboratory procedures

The laboratory pours the cast with implant analogs in place, shapes the titanium abutments with a milling machine, and mounts the acrylic resin prosthesis on the abutments. Because esthetic considerations are nonexistent in the posterior region of the mandible and the forces exerted are high, the laboratory prepares the prosthesis well out of occlusion (Fig 14-22c).

Delivery of prosthesis at chairside.

Within 72 hours, the prosthodontist removes the healing abutments and replaces them with the titanium abutments the laboratory has prepared. They are attached with a 20-Ncm torque, and the provisional prosthesis is cemented on the abutments. The prosthesis is carefully examined to ensure that it is out of occlusion both in centric relation and in excursive movements.



▲ **Fig 14-22** Provisional prosthetic phase. (a) Clinical situation at the beginning of the provisional prosthetic phase. The patient has arrived at the office with healing abutments in place. (b) Periapical radiograph taken after the provisional prosthesis has been placed in the mouth. Note the titanium abutments prepared by the laboratory and the platform switching implemented in the premolar area. (c) Clinical view 15 days after surgery. The prosthesis is well out of occlusion. (d) Verification of occlusion in excursive movement 15 days after surgery. (Prosthesis by Dr P. Raygot and G. Fournier.)

The patient is reexamined in the second week after placement of the provisional prosthesis (Figs 14-22c and 14-22d). The underocclusion in relation to the adjacent teeth and in mandibular excursive movements is considerable.

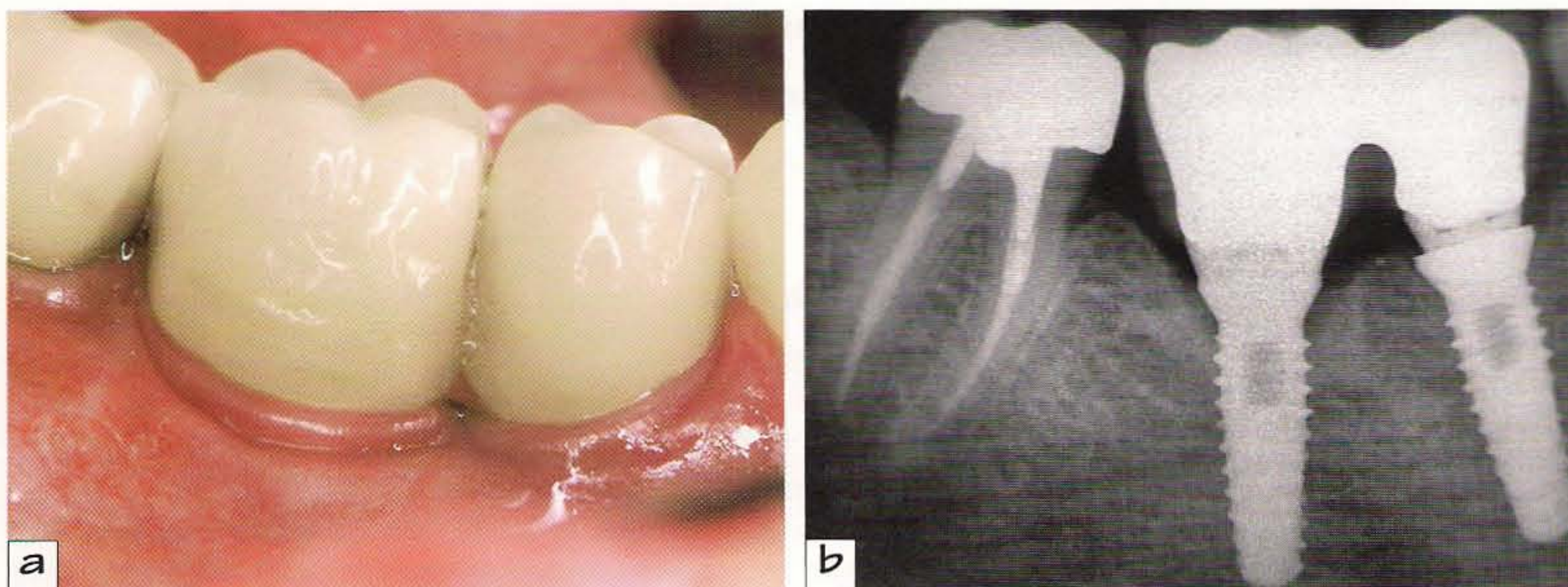
Control radiograph

After the prosthesis is placed in the mouth, a periapical radiograph is taken (Fig 14-22b); the prosthesis will serve as a baseline reference for future appointments.

Follow-up

The final restoration was finished 6 months after implant placement, a longer period than necessary for osseointegration. The delay resulted from the patient's complete satisfaction with the provisional prosthesis.

The soft tissues were in good health at 6 months (Fig 14-23a). The radiograph provided interesting information about the platform-switching protocol implemented in the premolar site, where the bone level was unchanged (Fig 14-23b). For the molar implant that was not equipped with the platform-switching design, crestal bone resorption, parallel to the breadth of the implant neck, had reached the level of the first thread (compare with Fig 14-22b).



▲ **Fig 14-23** Final prosthesis placed 6 months after delivery of the provisional prosthesis. (a) Final prosthesis just after placement. (b) Periapical radiograph taken at the 6-month visit. At the premolar site, platform switching has prevented resorption, but around the molar implant, where platform switching was not implemented, the classic vertical resorption has occurred. (Prosthesis by Dr P. Raygot and G. Fournier.)

Control visits

Patients are advised to eat soft foods for the first 6 to 8 weeks after the prosthesis has been placed.

Patients receive follow-up examinations:

- After 1 day to evaluate the occlusion and assess the beginning of healing.
- After 10 days to assess soft tissue healing and to remove sutures.
- After 1 month to assess the quality of soft tissue healing and to ensure that the patient is asymptomatic. It is not necessary to check implant stability either manually or with a device such as Periotest (Medizintechnik Gulden) or with Osstell (Osstell). If there is a specific reason for doing so, the screw-retained prosthesis can be removed. This action does not interfere with bone repair, but it is by no means routinely indicated. However, unseating of a cemented prosthesis is definitely contraindicated, because this could exert forces that would interfere with bone repair.
- After 2 to 4 months in the mandible, depending on whether the implants were placed in healed or extraction sites, to evaluate the status of osseointegration. More details of this assessment are provided in the section on the final prosthetic phase.
- After 6 months for maxillary restorations, to verify osseointegration and stabilization of the soft tissue conditions.

Management of complications

Complications can arise during the surgical phase, the prosthetic phase, or after delivery of the provisional prosthesis. These complications may be common to all options or specific to a given prosthetic option.

Complication during the surgical phase

Insufficient primary stability

If primary stability is insufficient (less than 35 Ncm), it is advisable to abandon the implementation of immediate loading for that implant. It is possible to consider substituting a longer or larger implant for the defective one.

Complications during the prosthetic phase

Complications common to all treatment options

- Hemorrhage during try-in of cylinders or abutments.
- Rupture of sutures. Sutures can rupture during the try-in of the cylinders or the abutments.

Complication specific to the screw-retained prosthetic options

Excessive buccal angulation of implants

When the implants are angled too far buccally, the screw access paths will emerge on the labial surface of the crowns. In the mandible and in the maxillary molar area, esthetic considerations are not relevant, but mechanical considerations should be a matter of concern because this positioning may weaken the occlusal plate. In the premolar region of the maxilla, the prosthodontist can mask these openings with a layer of resin composite and obtain a satisfactory provisional result.

It is also possible to manage this problem by preparing a cemented prosthesis in which the axes of the titanium abutments can be corrected. However, the laboratory must already have these titanium abutments or be able to procure them rapidly when a screw-retained prosthesis has been planned.

Complication specific to the cemented prosthetic options

Incomplete removal of excess cement

Residual excess cement can cause delayed inflammation of gingival tissue. The prosthodontist should be especially vigilant in removing debris from extraction sites, because cement trapped in alveoli around a newly placed implant can lead to peri-implantitis or even interfere with osseointegration.

Complications after delivery of the prosthesis

Complications common to all treatment options

Incomplete removal of impression material from gingiva

Residual impression material can cause gingival inflammation.

Fracture of acrylic resin prosthetic teeth

When a denture tooth breaks, the prosthodontist should determine the probable cause of occlusal trauma and eliminate it.

Fracture of provisional prosthesis

The prosthodontist should seek the probable cause, occlusal trauma, and eliminate the source.

Complications specific to the screw-retained prosthetic options

- Loosening of cylinder screws
- Loosening of abutment screws

Complications specific to the cemented prosthetic options

- Debonding of prosthesis
- Incomplete removal of excess cement

Implant failures and alternative treatments

In the maxillary posterior segments, failure of even one implant means failure of the restoration, because these are either single-unit crowns or short-span prostheses.

When an implant is identified as mobile, immediate action must be taken to avoid horizontal resorption of the crest. The implant can be unloaded and monitored for 3 months as described in chapter 8 (see page 101).

Usually, the mobile implant is removed. It can be replaced with another implant of larger diameter and, if possible, of greater length. In the maxilla, this new implant must still be compatible with applicable local esthetic requirements, which involve minimal distances from other dental units and to the buccal plate. The site is prepared for the new implant by cleaning and removal of all fibrous tissue.

If primary stability is satisfactory, 40 Ncm or greater, the new implant can be loaded immediately, and the provisional prosthesis can be returned to function. If primary stability is less than required, the implant does not have to be immediately loaded but can be left to osseointegrate in preparation for the final prosthesis. This will shorten the overall treatment time.

When esthetic considerations are not important, it is also possible to wait for 2 or 3 months of healing before a replacement implant is placed. In this case, a provisional removable partial denture is supplied to the patient in the interim.

Final prosthetic phase

The final prosthetic phase can begin 2 to 3 months after implant placement in the mandible and 6 months in the maxilla after the soft tissue has stabilized.

Osseointegration is verified radiographically and clinically. Radiographically, osseointegration is verified by the absence of a dark, radiolucent area around the implant.

Clinically, the implant is:

- Tested manually for mobility
- Assessed for the presence or absence of any clinical sign such as pain or local inflammation
- Tested with the application of a 20-Ncm countertorque
- Assessed with the Periotest or Osstell to measure implant stability (see chapter 4)

The information provided in chapter 11 regarding esthetic requirements for restoration of the maxillary anterior teeth applies to rehabilitation of the maxillary premolars.

As in all other sites, the prosthodontist assesses the amount of gingival recession that has occurred by the end of the provisional prosthetic phase. When recession is slight, the final restoration can readily be fabricated to accommodate the change on the basis of the new impression. The impression will take into account the new margins and the emergence profiles will be developed in conformity with them.

In maxillary posterior segments, cementation is the preferred method of attaching the final prostheses, for the reasons explained in chapter 7.

To prepare the final prosthesis, the prosthodontist removes the provisional prosthesis and takes an impression in the usual way on the implant neck. This impression is sent to the laboratory for construction of a ceramometal prosthesis. When the prosthesis is completed, the prosthodontist makes any necessary adjustments at chairside, cements the prosthesis, and verifies its occlusion with conventional methods.

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Chapter 15

NANO TITE: A NEW TYPE OF BIOACTIVE SURFACE

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It has long been known that micromovements during the healing phase affect bone response at the bone-implant interface.¹ In the same way, it has been known that excessive micromovements will prevent osseointegration from taking place, because they lead to the development of a fibrous encapsulation around the implant (see chapter 2). However, only 15 years ago did clinicians begin to understand the role played by the implant surface in the toleration of micromovements. Within that tolerance, a factor of 10 separates the best-performing surfaces from the poorest. Researchers have demonstrated the superiority of bioactive surfaces in many animal studies.¹ For an implant with a hydroxyapatite (HA) coating, the tolerance to micromovement was found to lie somewhere between 250 and 500 μm . For machined surfaces it is less than 30 μm (see Fig 2-4).

Bioactive surfaces have been traditionally prepared with the plasma-spraying method, which leaves about a 50- μm -thick layer on the implant surface. This method of deposition is carried out under high temperatures greater than or equal to 1,000°C. The coating then obtained is a composite layer with an HA base that is more or less denatured (non-stoichiometric), associated with a number of other derived components. The quantity of these components varies from 2 to 10, depending on the deposition conditions. They include, to name only the best known, amorphous HA, oxyapatite, α - and β -tricalcium phosphates, tetracalcium phosphate, and calcium hydroxide. The biologic properties of the bioactive coating depend on the solubility of its components, which, in turn, depends on the physical parameters of the deposition. It is important to note that the technique of plasma deposition is complex and sophisticated, calling into play up to 100 different parameters.¹ It is not surprising, therefore, that a coating prepared by one manufacturer differs in its properties from one prepared by a competitor.

In May 2001, the French Health Security Agency for Health Products banned the use of a particular HA-coated cylindrical implant. The agency was motivated to issue this interdiction because of the long-term, 3- to 5-year failure rates and complications that had been associated with this product.

The principal problems with traditional bioactive coatings reside in their thickness, which is about 50 μm , and structure. They are composed of interlocked grains of HA surrounded by more

soluble materials, much like a brick wall that consists of baked blocks (the HA grains) embedded in cement (the denatured substances).

When gingiva recedes over time around such a coated implant, the bioactive covering of the implant is exposed to dental plaque. The bacteria of dental plaque, which have a high affinity for HA, rapidly colonize the coating and begin dissolving it just as they do with tooth enamel. However, the bacteria do not proceed layer by layer from the exterior inward. Instead, they attack insidiously, seeking out the zones of least resistance, slipping deeply between the crystallized HA grains and dissolving the soluble materials that were binding the coating together. The bioactive layer in its entirety becomes fragile. Once it becomes fragmented and weakened, the coating can no longer help to distribute the occlusal forces exerted on the implant.

What is worse, the infection spreads stealthily toward the apex of the implant, leaving no warning signs at the crest. The progress is difficult to arrest because infection spreads simultaneously in every direction. Especially the cylinders, without threads, are bound to the peri-implant bone only through the HA layer. When the coating fails, the implant becomes mobile and fails.

▼ Development of a New Bioactive Nanotechnology-Based Coating

To solve these long-term issues that are specific to plasma-spray coatings, some researchers have conceived a bioactive coating that is soluble in the short term.¹ Others directed attention to nanotechnology and investigated the properties of a new coating called *NanoTite* (Biomet 3i).²⁻⁶

This bioactive coating is gained from a deposit of discrete crystals of calcium phosphate (discrete crystalline deposition) obtained by a sol-gel route; it contains calcium phosphate particles of 20 to 100 nm. The word *discrete* indicates that the coating is not made up of a continuous layer of calcium phosphate but of individualized nanograins, covering approximately 50% of the roughened Osseotite (Biomet 3i) surface of the implant (Fig 15-1). The appearance of the surface, in its structure and color, remains unchanged to the naked eye; only under great magnification can the nanometric crystals be observed.

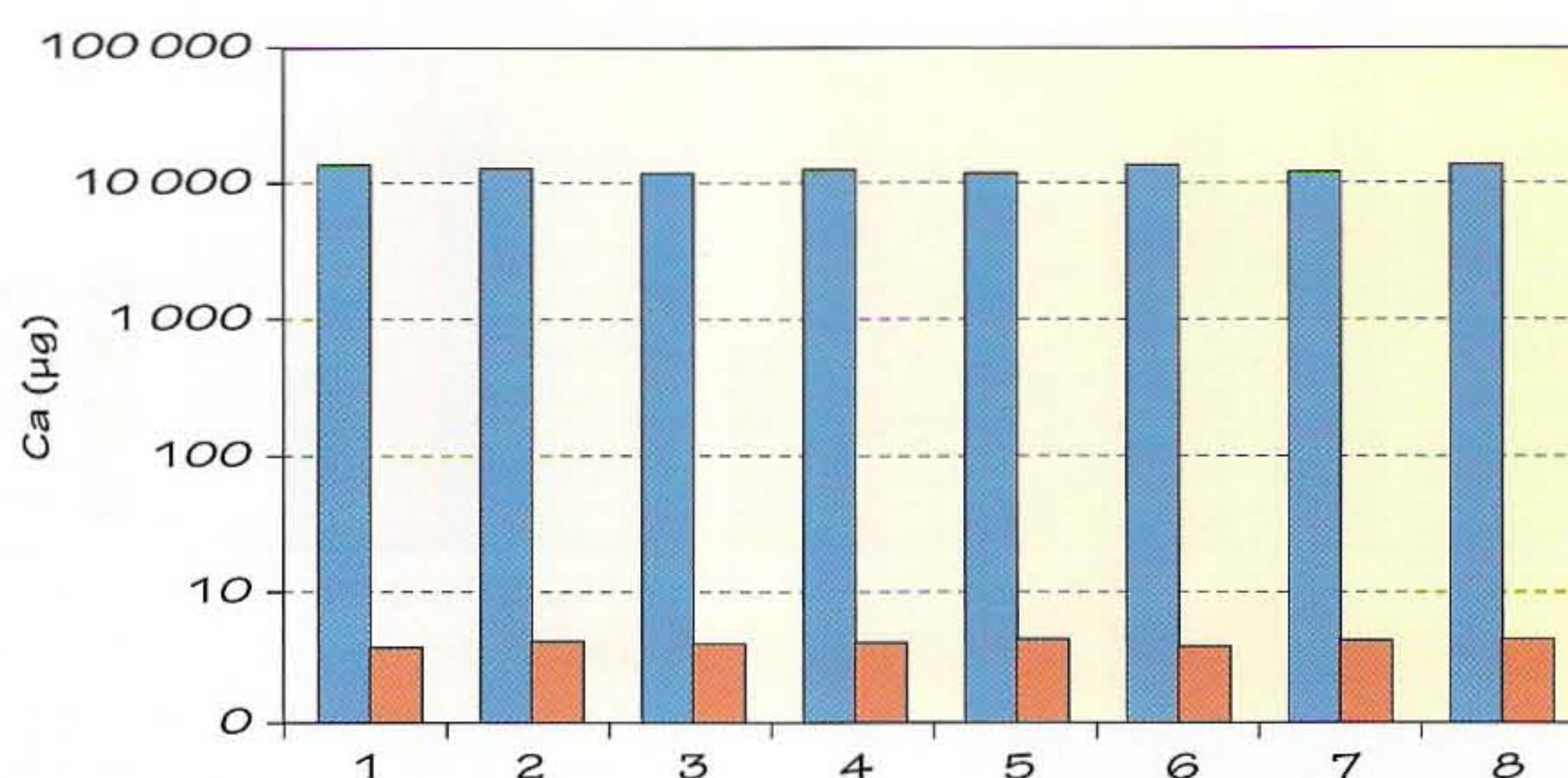
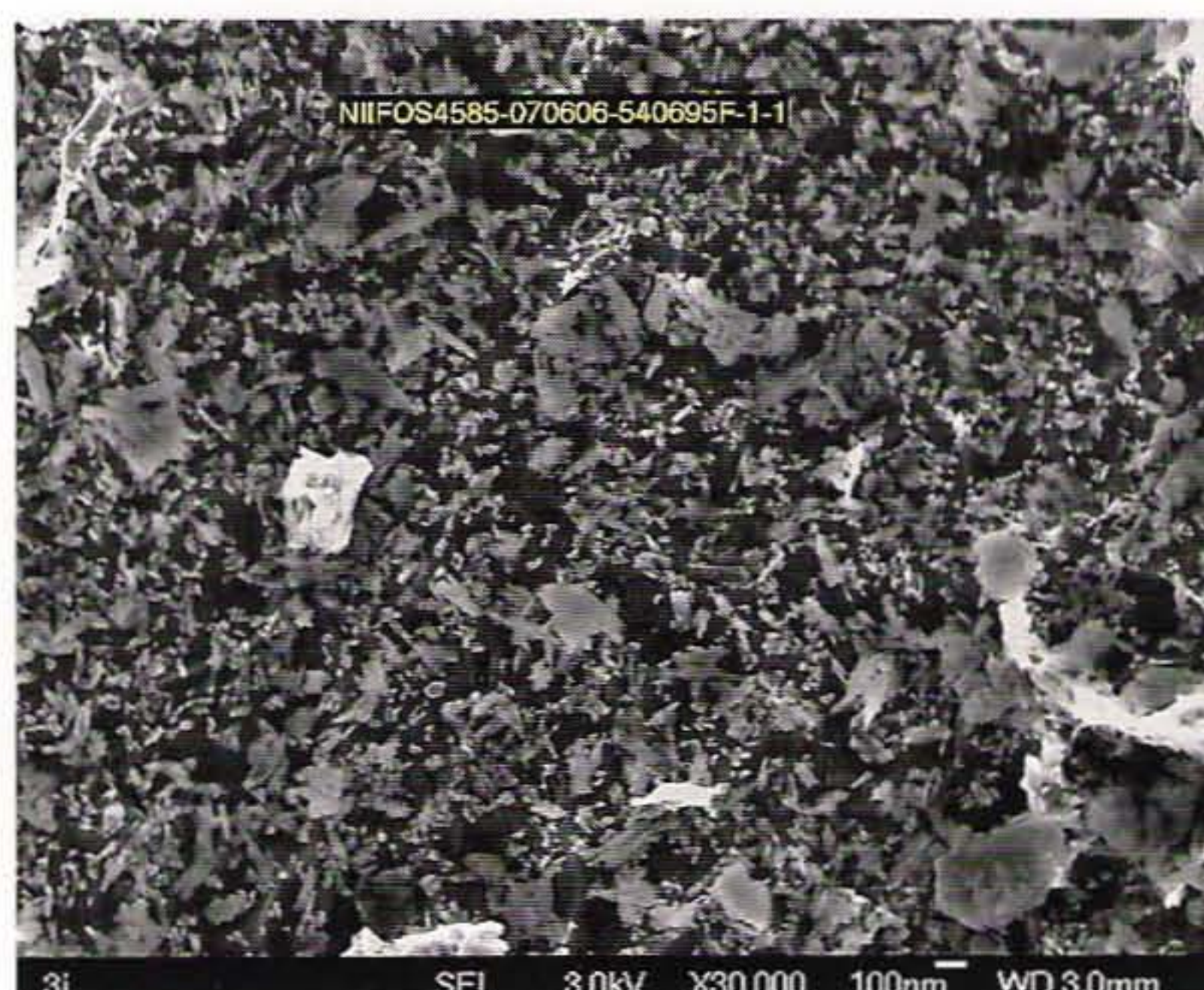
The bioactive layer covers the entire implant surface that comes into contact with bone except the implant neck, abandoning the previous hybrid concept of leaving the three most coronal threads untreated.

In vitro studies

The first step in this research was an in vitro study.² The goal was to compare the dissolution of NanoTite and plasma-spray coatings deposited on implants made of titanium-aluminum-vanadium (TAV) alloy. To measure the total respective quantity of calcium phosphate of the coating, eight implants from each group were immersed in a molar solution of hydrochloric acid that totally dissolved the deposited calcium phosphate. The amount of calcium in the solution was measured by adsorption spectrophotometry. The results showed calcium concentrations of 3.81 µg and 11,551 µg from the NanoTite and plasma-sprayed implants, respectively (Fig 15-2); this means that the amount of the material dissolved from the plasma-sprayed coating was 3,000 times greater than that dissolved from the NanoTite surface. These findings emphasize the structural difference between the two types of coating.

In a second experiment,² implants were immersed in saline solutions of various pH concentrations. The pH varied between 4 and 7 to simulate the physiologic pH level of 7 as well as the post-operative conditions, where the pH drops down to about 4. The calcium in solution was measured at adjusted pH levels of 4, 5, 6, and 7. The results confirmed the data of the previous experiment (Fig 15-3); higher total quantities of calcium in the solution were found for the plasma-sprayed coating than for NanoTite. The results demonstrated both the greater stability of the NanoTite coating, especially at a physiologic pH, at which dissolution is virtually nonexistent, and the pluriphasic character of the plasma-sprayed coating.

► **Fig 15-1** NanoTite coating. The NanoTite coating is made up of nanoparticles of calcium phosphate (light gray) deposited on an Osseotite surface (black background). The etched surface is still visible in the background because the overlayer is not uniform. This view clearly shows the nanometric and discrete character of the bioactive coating (original magnification $\times 30,000$; 100-nm scale).

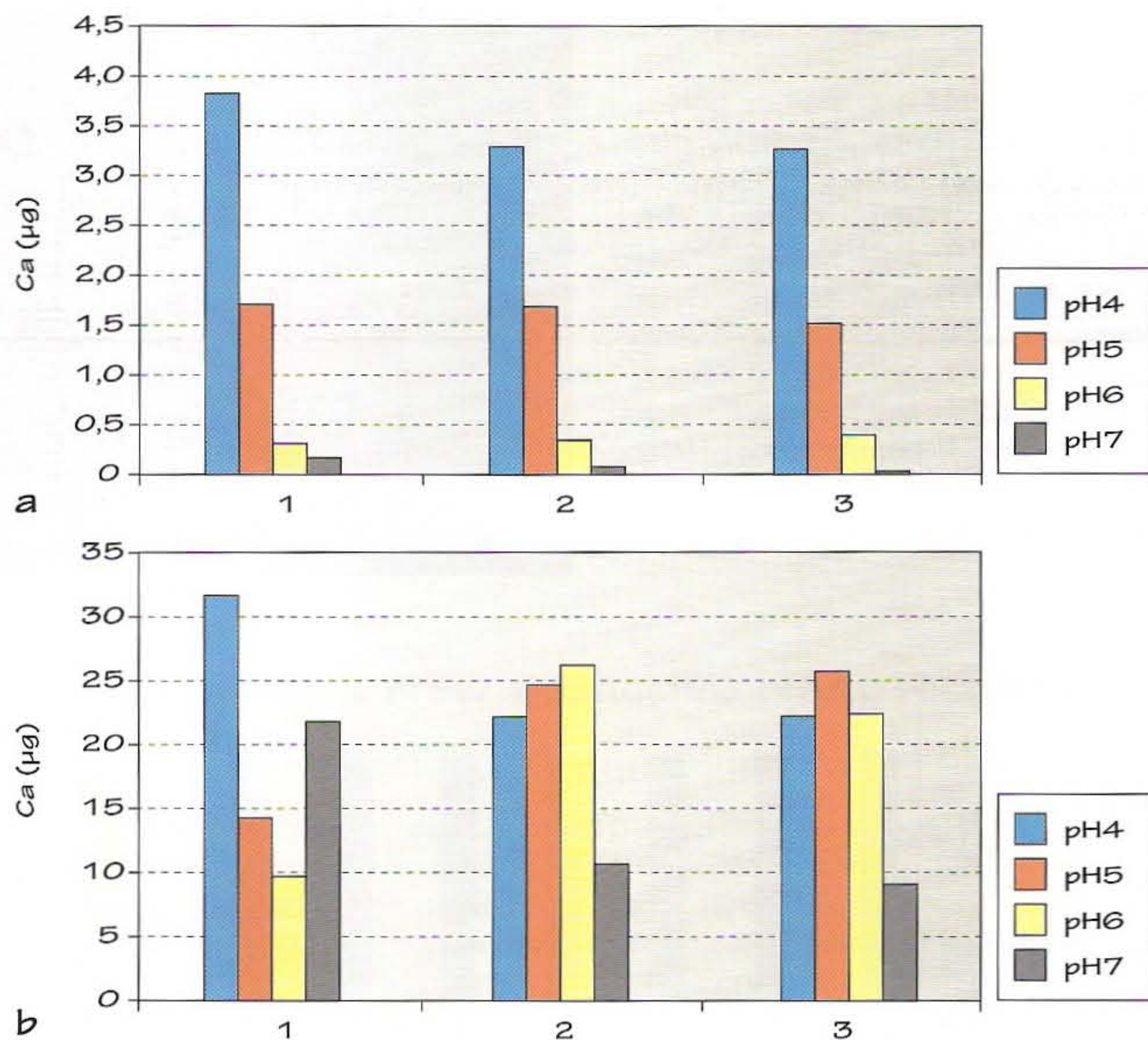


▲ **Fig 15-2** Dissolution of the NanoTite and plasma-sprayed coatings in a hydrochloric acid solution. The sample size of each group was 8 (numbered 1 to 8). The concentration of calcium released by NanoTite (red) and a plasma-sprayed coating (blue) was measured. The concentration of calcium (Ca) released by the plasma-sprayed coating is about 3,000 times higher than that released by NanoTite. (Data from Pezeshki et al.²)

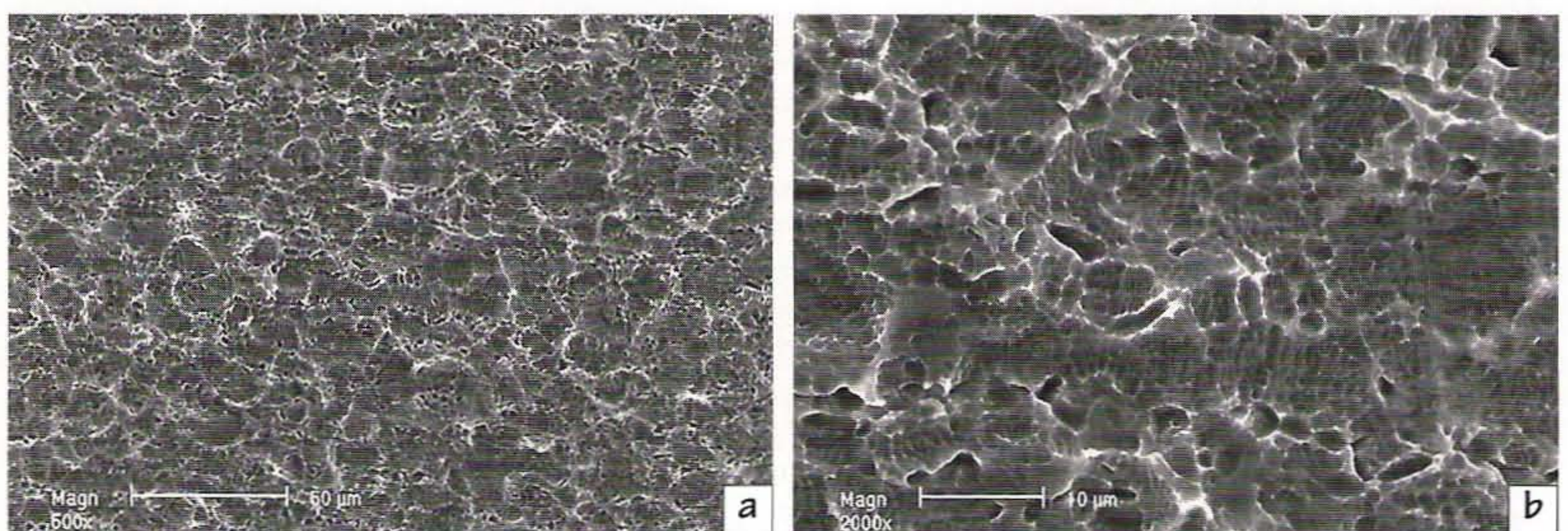
These two experiments suggest that the clinical failures observed in the past because of the massive release of calcium phosphate from the bioactive HA coating can now be avoided.

In vivo studies

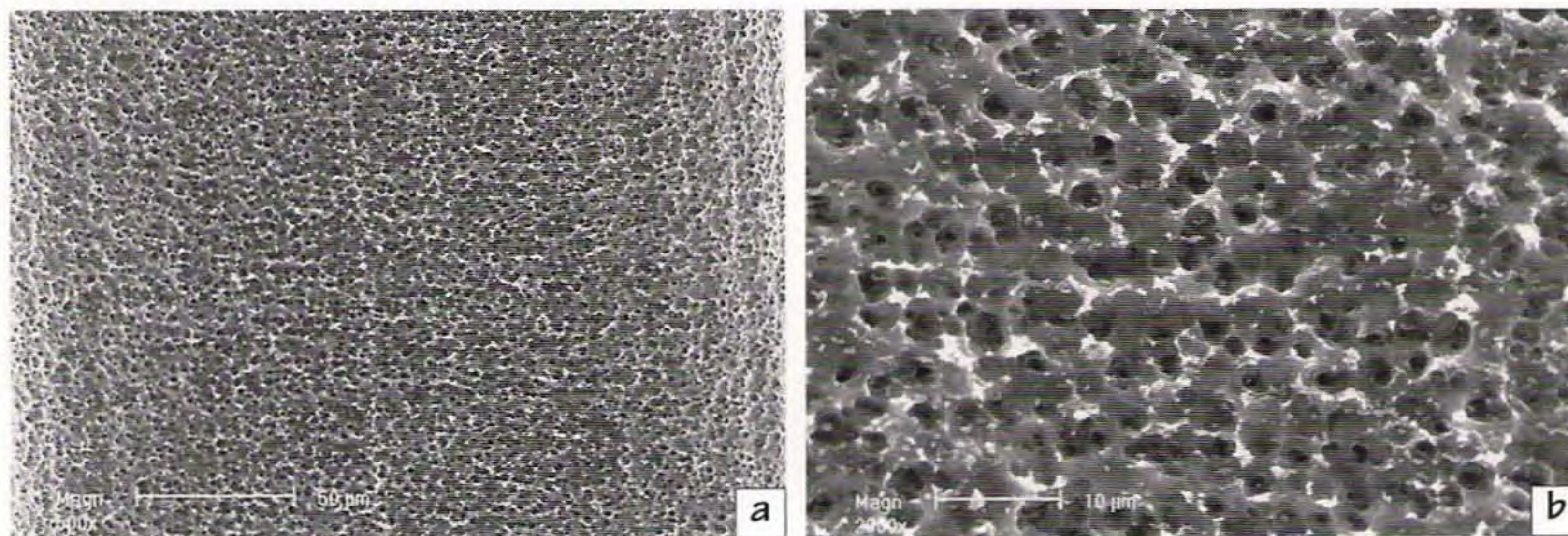
Another set of experiments, this time in vivo, dealt with four surface groups that were compared in a T-chamber model.³ The degree of bone fill along the length of the chamber during a 9-day period was compared in rat femurs. The four surfaces were composed of an Osseotite surface type prepared from either commercially pure titanium etched with a sulfuric acid/hydrochloric acid (H_2SO_4/HCl) solution (Fig 15-4) or from TAV alloy etched with a hydrochloric acid/hydrofluoric acid (HCl/HF) solution (Fig 15-5) with and without the NanoTite bioactive layer. The results showed that, systematically, the percentage of bone contact was higher with the NanoTite surface, up to 150%. In addition, no difference was found between the commercially pure titanium and the alloy surfaces, whether or not they were covered with the NanoTite bioactive layer.³



▲ **Fig 15-3** Dissolution of the NanoTite and plasma-sprayed coatings in a saline solution as a function of pH. The sample size of each group was 3 (numbered 1 to 3). (a) Dissolution of the NanoTite coating. (b) Dissolution of the plasma-sprayed coating. The concentration of calcium (Ca) released by the plasma-sprayed coating is greater than the concentration released by NanoTite. At a pH of 7, the dissolution of NanoTite approaches zero. (Data from Pezeshki et al.²)



▲ **Fig 15-4** Surface topography of etched commercially pure titanium. (a) There is a high density of pits (original magnification $\times 500$). (b) The pits are not deep but are quite close to each other (original magnification $\times 2,000$). (Courtesy of Dr M. Bischof.)



▲ **Fig 15-5** Surface topography of etched titanium alloy. (a) The shape of the pits is different in the alloy (original magnification $\times 500$). (b) The density of pits is lower in the alloy; however, the pores seem deeper than they are in the etched commercially pure titanium (see Fig 15-4b). The bright zones correspond to the β phase of the alloy (original magnification $\times 2,000$). (Courtesy of Dr M. Bischof.)

► **Fig 15-6** NanoTite commercially pure titanium sample tested in traction. An orifice was prepared in this metal sample to attach the tested surface to the tensile device. This sample presented one of the highest adhesion values. The rupture took place in bone; adhesion at the interface was stronger than bone cohesion. (Courtesy of Biomet 3i.)

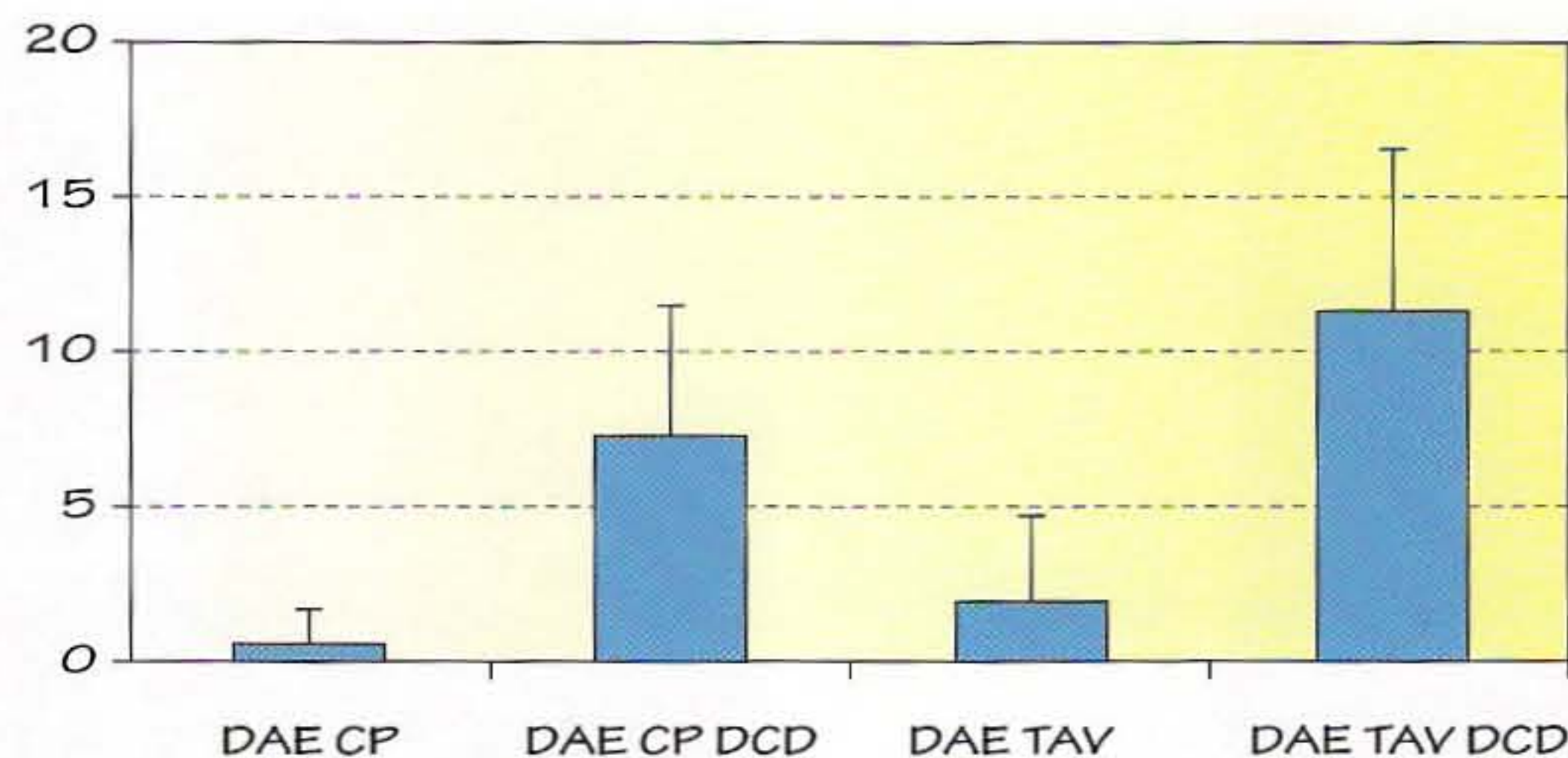


After this first in vivo experiment dealing with the extent of bone apposition, the quality of the micromechanical anchorage between these four surfaces and bone was tested using the same animal model.⁴ Samples with different surface treatments were placed in contact with the femurs of rats (Fig 15-6). After 9 days, the adhesion of the interface was measured by a direct tensile test. The NanoTite surfaces produced the highest tensile values, 11.3 N for the NanoTite titanium alloy and 7.1 N for the NanoTite commercially pure titanium. The lowest measurements, 0.6 N and 1.9 N, were recorded for the commercially pure titanium and the titanium alloy groups, respectively (Fig 15-7).

As a rule, detachment between bone and NanoTite occurred within the bone as a cohesion rupture rather than at the bone-implant interface. This type of detachment indicates that NanoTite surfaces have the capacity to create a bond at the interface, while the merely etched surfaces do not.⁴ This experiment also indicated that the etched titanium alloy surface produces a better interfacial bond than does the etched commercially pure titanium.

All the experiments tended to demonstrate the bioactive properties of the NanoTite surface. This surface treatment, especially when it is applied to titanium alloy, should be able to increase the tolerance to micromovements in the same way that plasma-sprayed bioactive surfaces do. This new bioactive surface should be particularly suited for immediate-loading protocols because it should nurture the interfacial bone reaction that leads to osseointegration.

In fact, bioactivity for the NanoTite surface has been demonstrated in humans as well. Goené et al⁵ retrieved mini-implants placed in the posterior maxilla. After 4 and 8 weeks of healing, the



▲ **Fig 15-7** Tensile measurements of the four tested surface groups. The average measured values are statistically significantly different. DAE CP = etched commercially pure titanium; DAE CP DCD = NanoTite etched commercially pure titanium; DAE TAV = etched titanium alloy; DAE TAV DCD = NanoTite etched titanium alloy. (Data from Mendes et al.⁴)

NanoTite implants ($n = 9$) had a higher bone-implant contact than the Osseotite implants, 15.5% vs 44.5% at 4 weeks and 25.6% vs 42.1% at 8 weeks.⁵ These results were confirmed by Orsini et al⁶ in the same model (15 patients, $n = 20$) when after 8 weeks the bone-implant contact was higher for the NanoTite implants than for the nontreated Osseotite implants, 19.0% vs 32.3%.

▼ Clinical Application of the NanoTite Surface to Immediate-Loading Protocols

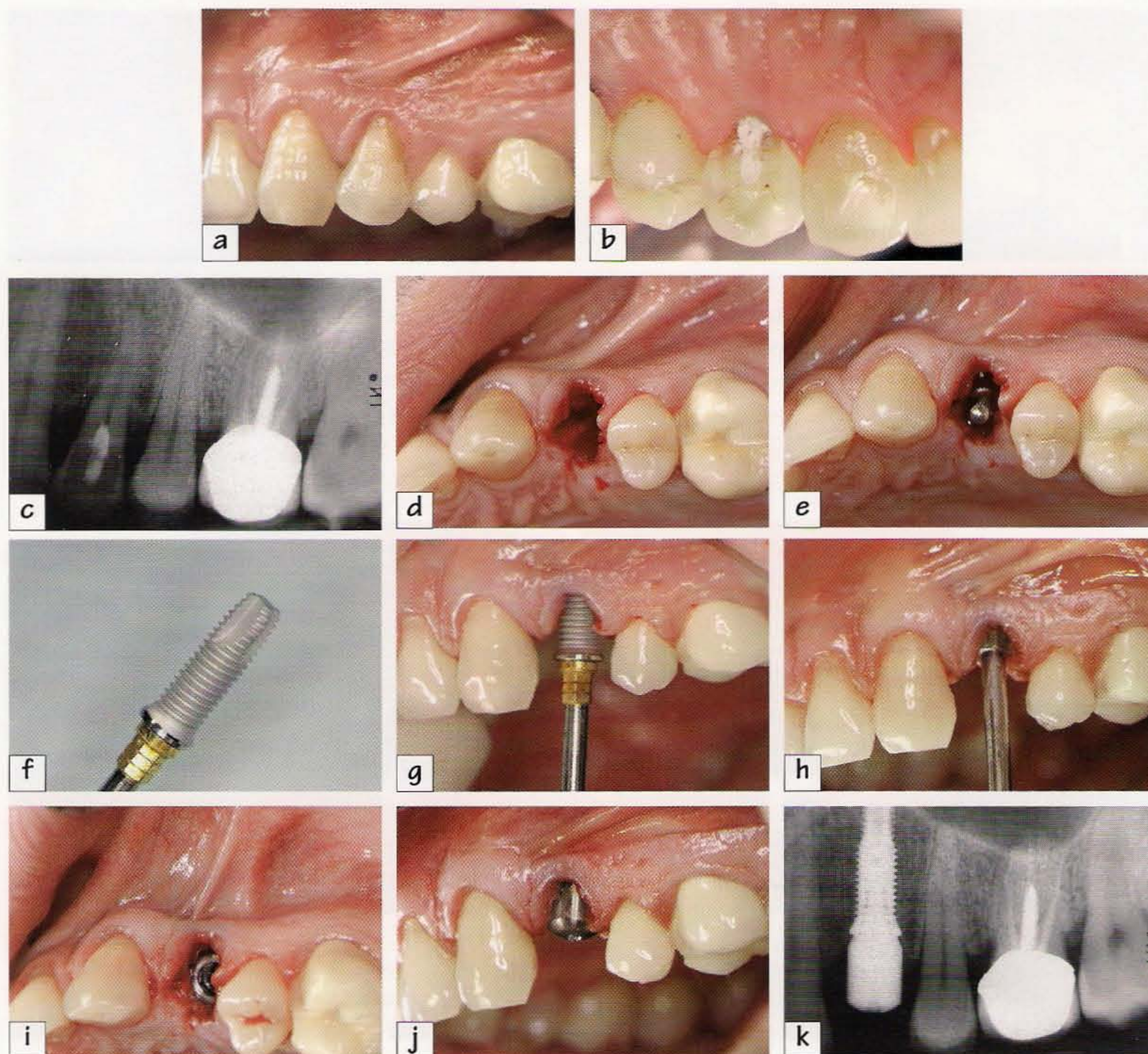
Immediately loaded single crown in the posterior maxilla

A patient presented with a subgingival fracture of the lingual cusp of his maxillary first premolar (Figs 15-8a and 15-8b). The tooth had to be extracted. Because this tooth was in the esthetic zone, he asked for an immediate restoration of the tooth. After a radiograph verified that the available bone height and width were adequate (Fig 15-8c), an immediate-loading protocol with immediate placement was proposed. It was planned to follow option 2 of the prosthetic treatment, described in chapter 14 (see pages 324 to 329). The screw-retained provisional crown should be completely prepared in the laboratory and placed within 24 to 48 hours after surgery.

After the nontraumatic extraction of the tooth and cleansing of the alveolus, the surgeon placed a 13-mm-long Prevail NanoTite Certain implant (Biomet 3i) with a 4-mm-diameter body and a 5-mm-diameter neck and internal connection (Figs 15-8d to 15-8k). Immediately after surgery, the prosthodontist took an impression with an internal connection impression coping in place. This was sent to the laboratory for fabrication of a provisional screw-retained crown implementing the platform-switching concept. The next morning, the prosthodontist placed the crown and took it out of occlusion (Fig 15-9).

Immediately loaded prosthesis in the edentulous maxilla

A patient whose only remaining maxillary teeth were two molars, one on each side, sought rehabilitation of his otherwise edentulous maxilla. After the amount of available bone was assessed with a computerized tomography scan, a treatment plan was proposed. It included extraction of the two



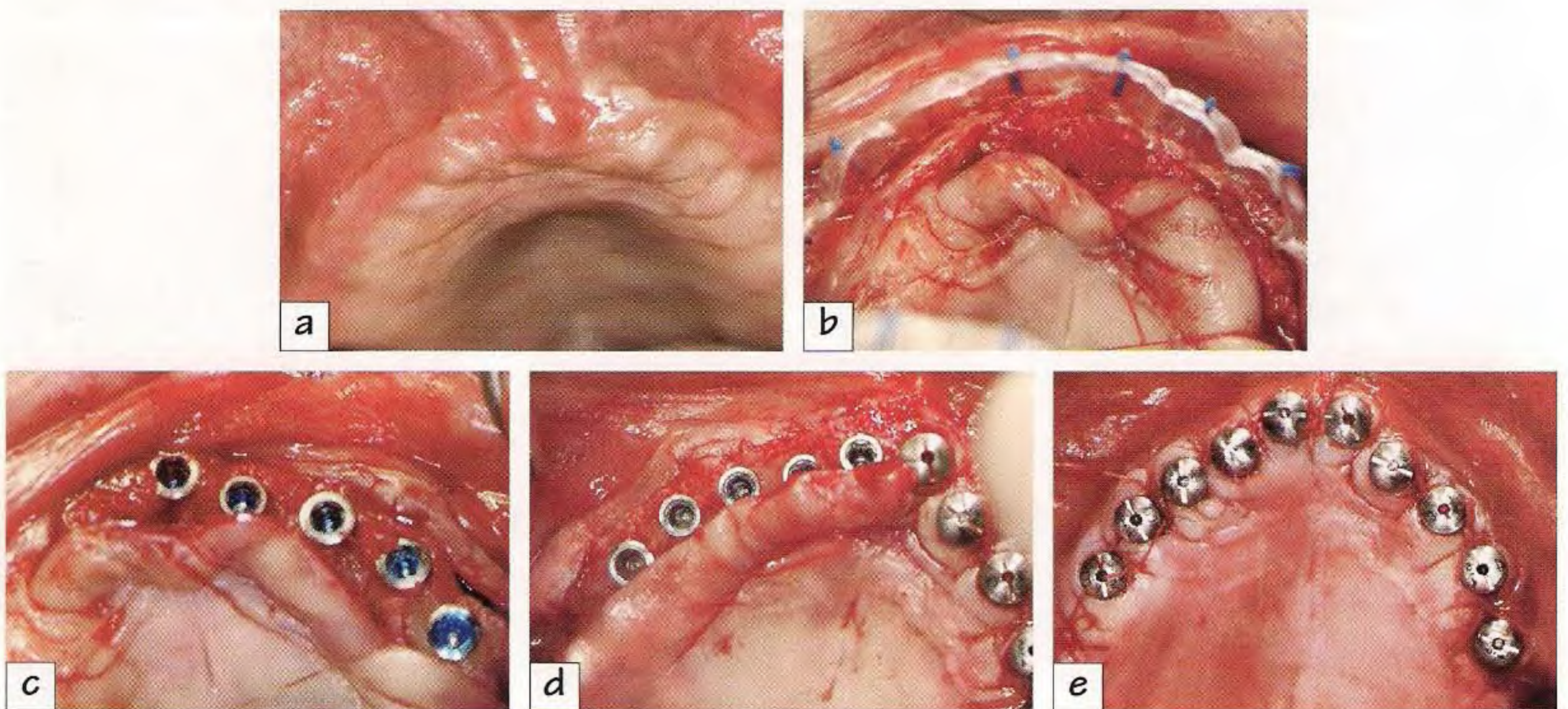
▲ **Fig 15-8** Surgical phase of rehabilitation of a maxillary left first premolar. (a) Buccal view of the clinical situation before extraction. (b) Palatal view of the clinical situation before extraction. (c) Preoperative radiograph. There is enough bone below the sinus to host an implant. (d) Alveolus after extraction of the maxillary left first premolar. (e) Buccopalatal orientation of the implant as shown by a direction indicator. (f) NanoTite 4/5 × 13 Prevail Certain implant. It resembles a standard Prevail implant with the naked eye. (g) NanoTite Prevail implant placed with the help of an implant carrier. (h) Final seating of the implant with the aid of the implant carrier. (i) Implant fully seated in the alveolus. (j) A 6-mm-long healing abutment placed in the implant. Note the absence of sutures. The surgical phase is now completed. (k) Control radiograph. Platform switching has been implemented by using an abutment with the same color code as the implant.

molars, placement of 10 implants, and immediate loading of the implants with a complete-arch prosthesis. The protocol would follow prosthetic treatment option 1, described in chapter 12 (see pages 239 to 246). A provisional screw-retained prosthesis, fabricated entirely in the laboratory, would be delivered 48 to 72 hours after surgery.

After a full-thickness flap was raised (Figs 15-10a and 15-10b), 10 implants were placed. Five were Prevail NanoTite Certain implants, with a body that was 4.0 mm in diameter and a neck that was 5.0 mm in diameter and internal connection, incorporating the platform-switching concept. Two



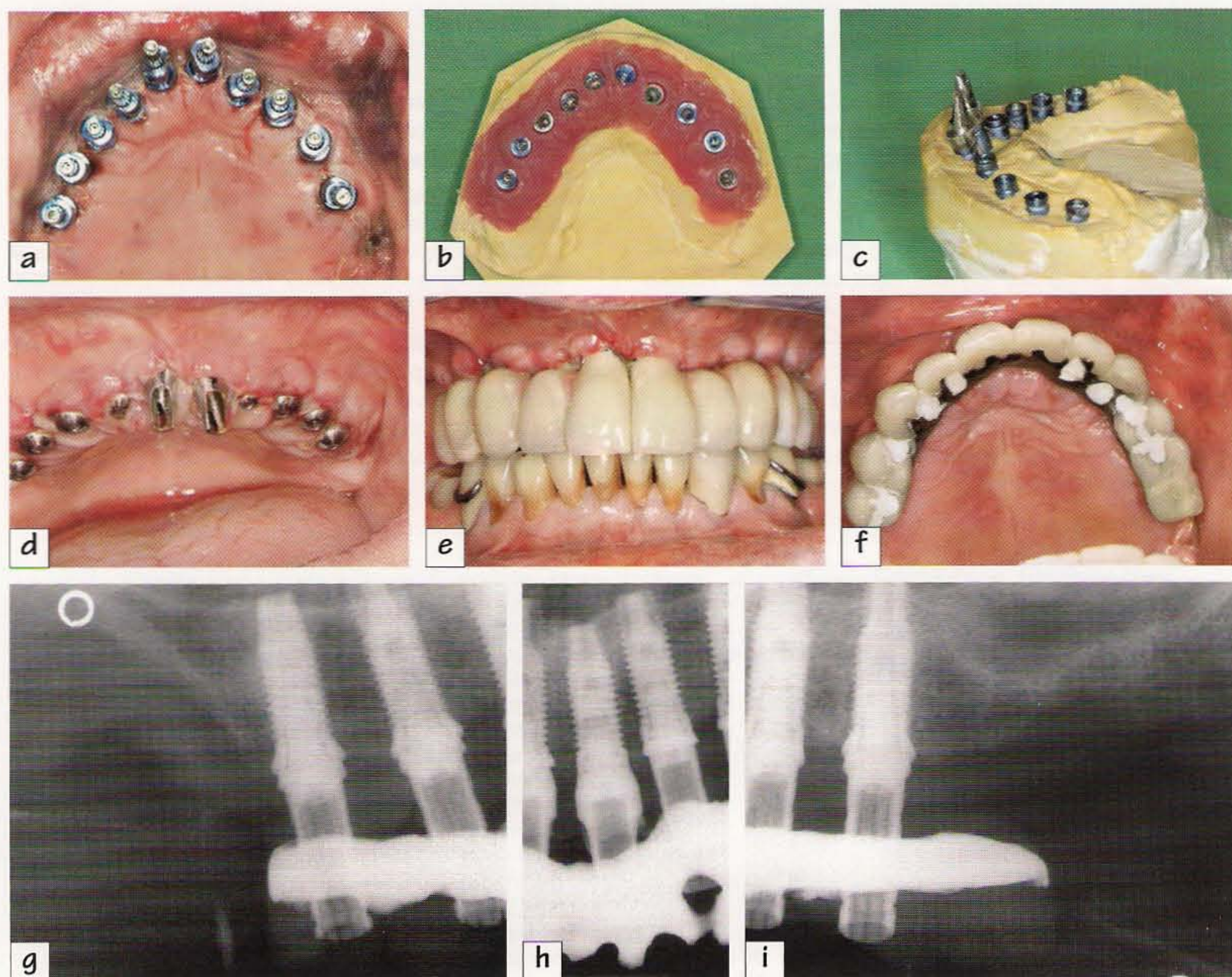
▲ **Fig 15-9** Provisional screw-retained crown. (a) Buccal view of a laboratory-prepared acrylic resin crown. It is well out of occlusion. (b) Occlusal view of the crown in place. (c) Radiograph taken at immediate loading. Note the platform-switching following placement of the provisional titanium abutment and the pledget of cotton placed beneath the provisional restorative material. (Prosthesis by Dr G. Rousseau.)



▲ **Fig 15-10** Surgical phase of rehabilitation of an edentulous maxilla. (a) Clinical situation before treatment. (b) Flap and surgical guide. (c) First five implants placed, all on the left side. (d) Five implants placed on the right side before flap closure. (e) Postoperative view of all 10 implants in place. Note the two extraction sites left by the extracted molars.

implants were 11.5 mm long; the other three were 13.0 mm. The first five implants were 4.0-mm-diameter cylindrical NanoTite implants. Four were 11.5 mm long and one was 13.0 mm. All implants were placed level with the bone crest (Figs 15-10c and 15-10d). Healing abutments were placed, and the gingiva was sutured around them (Fig 15-10e).

The next morning, the prosthodontist took a pick-up impression with internal connection impression copings (Fig 15-11a). The impression was sent to the laboratory for fabrication of a screw-retained complete prosthesis. The laboratory poured a cast with prosthetic gingiva (Fig 15-11b). The screw access paths for the two central incisors emerged on their buccal surfaces. Because



▲ **Fig 15-11** Provisional prosthetic phase of rehabilitation of an edentulous maxilla. (a) Placement of 10 impression copings before impression procedures. (b) Cast poured with prosthetic gingiva. The long axes of the two most anterior implants are not compatible with palatal emergence of the screw access paths. (c) Preparation of two Gingihue titanium abutments (Biomet 3i) for the central incisors. They easily rectify the excessive palatal angulation of the implants. The axes of the remaining implants are compatible with the desired pathways for screw emergence. Emergence is palatal for the other implants in the anterior region and occlusal in the posterior area. (d) Two anterior abutments positioned in the mouth. (e) Buccal view of the provisional maxillary prosthesis. (f) Occlusal view of the provisional prosthesis, which is both cemented and screw-retained. (g to i) Radiographs taken after attachment of the provisional prosthesis. (g) Right posterior segment. (h) Anterior segment. (i) Left posterior segment. (Prosthesis by Dr P. Raygot and G. Fournier.)

this could be corrected with ease by titanium abutments (Fig 15-11c), it was decided that a mixed cemented and screw-retained prosthesis would be the best solution. The prosthesis was ready within 72 hours after surgery.

Titanium abutments were screwed into the two central implants to provide anterior support for the prosthesis (Fig 15-11d), and temporary cement was used to attach the mixed prosthesis anteriorly. In the posterior part, the prosthesis was screwed in the other implants (Figs 15-11e and 15-11f). After scrupulous removal of excess cement, the occlusion was adjusted and control radiographs were taken (Figs 15-11g to 15-11i).

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Index

Page references followed by "b" indicate boxes, "f" indicate figures, and "t" indicate tables

A

- Abutments
 - in edentulous anterior maxilla, 78f, 213f
 - in edentulous mandible
 - with extraction sites, 125, 125f
 - with healed sites, 121f, 122
 - immediate occlusal loading abutments, 121f, 122, 131, 133f
 - in edentulous maxilla
 - healing abutments, 256, 256f, 265, 267f
 - immediate occlusal loading abutments, 244-245, 246f, 250, 252f
 - final
 - description of, 86-87
 - final prosthesis on, 273, 274f
 - healing, 178, 179f, 210, 211f, 236, 238, 256, 256f, 284, 285f, 296
 - manipulation of, 75, 77, 86
 - materials for, 84, 85f-86f
 - provisional
 - chairside preparation of, 193, 194f, 204, 205f
 - description of, 85-87
 - final prosthesis on, 273
 - shape of, 85-86
 - size of, 86f
 - titanium, 85f-86f, 205f, 267f, 351, 351f
 - transgingival, 236, 238
 - UCLA, 84, 153, 153f
 - zirconia, 86f
- Alveolar depth, 177f
- Alveolar ridge
 - computerized tomography evaluations, 117, 119f
 - in edentulous mandible patients, 117, 118f
 - resorption of, 154f
- Alveolus-implant gap, 62, 63f
- Anterior mandible, edentulous. *See* Edentulous anterior mandible.
- Anterior maxilla
 - edentulous. *See* Edentulous anterior maxilla.
 - implant placement in, 63-64, 65f-66f
 - single-crown replacement in, 26-27
- Antibiotic prophylaxis, 60, 61f

B

- Bioactive surfaces, 12, 343-351
- Biologic width, 47-49, 48f, 50f, 87
- Bite tray, 210, 211f
- Blade implants, 8
- Bone
 - drilling sequence, 35f-36f, 35-36
 - primary stability affected by, 34-35
- Bone crest
 - abutment manipulation effects on, 75, 77
 - computerized tomography evaluations, 123f

- contact point and, relationship between, 72, 73f
- horizontal resorption of, 271
- implant-abutment interface at, 53, 53f, 74
- Prevail implant effects on, 83f
- Bone healing
 - physiology of, 11f
 - stress necessary for, 10
 - submerged, 9, 9t, 97
- Bone necrosis, 10
- Bone profiler, 121f, 122, 124, 177-178, 178f-179f, 183, 184f, 236, 238, 284
- Bone resorption
 - after tooth extraction, 4, 5f
 - chronic infection as cause of, 80
 - cortical plate thickness affected by, 47
 - horizontal, 52f
 - at implant-abutment interface, 53, 74-75, 80-81
 - mechanical stress and, 49, 51, 96
 - micromovement effects on, 10
 - platform switching effects on. *See* Platform switching.
 - vertical, 53
- Bone-implant interface
 - force minimization, 36-42
 - machined titanium surfaces at, 52, 52f
 - mechanical stress at, 30f
 - micromovement at, 29, 30f, 96
 - primary stability of. *See* Primary stability.
- Brånemark, 7b, 7-10, 9b, 9t
- Buccal cortical plate, 53, 61
- Buccal plate
 - encroachment on, 219, 268
 - implant-abutment junction and, distance between, 75, 76f
 - resorption of, 75
- Buccolingual axis
 - in completely edentulous arch, 55, 55f
 - in extraction site, 61-62
- Buccopalatal distance, 76f
- Buccopalatal positioning, 57-58, 58f, 65f

C

- Cemented final prostheses
 - cemented provisional prosthesis and, 93-94, 94f
 - screw-retained provisional prosthesis and, 92, 93f
- Cemented provisional prostheses
 - cemented final prosthesis and, 93-94, 94f
 - description of, 90-91
 - edentulous anterior maxilla. *See* Edentulous anterior maxilla.
 - edentulous mandible. *See* Edentulous mandible.
 - edentulous maxilla. *See* Edentulous maxilla.

- edentulous posterior mandible and maxilla. *See* Edentulous posterior mandible and maxilla.
- screw-retained final prosthesis and, 93, 93f
- Communication, 20-21
- Complete denture, 1, 3f, 258f-259f
 - metallic reinforcement of, 39, 40f
 - rotational movements for, 38f
- Conical implants, 34
- Conversion prosthesis technique, 109, 109f-110f
- Coronoapical axis, 183
- Coronoapical position, 53, 53f, 55-56, 56f, 59-60, 75
- Cost analysis and comparisons, 24-26
- Crestal bone. *See* Bone crest.
- Crest-to-papilla distance, 72f, 72-73
- Cylindrical implants, 34

D

- Delayed loading
 - of edentulous mandible, 19f
 - gingival recession after, 71
 - immediate loading vs, 17
 - for single-crown replacement in anterior maxilla, 26-27
 - support for, 10t
- Dental laboratory, 21, 25
- Dental technician, 20
- Denture. *See* Complete denture; Fixed partial denture.

E

- Economics, 23-24
- Edentulous anterior mandible
 - abutments in, 284, 285f
 - case reports of, 283-287
 - cemented provisional prosthesis, 281-282, 292-297, 295f-297f, 301
 - clinical conditions associated with, 278
 - complications associated with, 298, 300-301
 - considerations for, 283
 - control visits, 297-298
 - extraction sites, 283-286, 285f
 - final prosthetic phase, 301-302
 - healed sites, 286-287, 288f
 - healing abutments in, 284, 285f
 - immediate loading in, guidelines for, 282-283
 - implant failure, 301
 - implant placement
 - in extraction sites, 284, 285f
 - in healed sites, 286-287, 288f
 - screw-retained provisional prosthesis, 280-281, 287, 289-292, 300-301
 - treatment options for, 279-302
- Edentulous anterior maxilla
 - case reports of, 174-190
 - causes of, 161, 162f
 - cemented provisional prostheses
 - decision nodes regarding, 164-165
 - final prostheses, 221

placed immediately after surgery, 169f, 169–170, 201–206, 202f–205f
 placed within 24 to 48 hours after surgery, 170–173, 171f, 173f, 206–214, 208f–214f, 216–218
 soft tissue changes around, 207f
 thick periodontal biotype and, 212, 214, 215f
 clinical conditions, 161, 162f
 complications associated with, 218–220
 control visits for, 218
 extraction sites
 multiple, 183, 185–189
 single-tooth replacement in, 175f–180f, 175–180
 fixed partial dentures in, 162f
 healed sites, 181–183, 182f
 immediate loading in, guidelines for, 174–190
 implant failure in, 220–221
 screw-retained provisional prostheses
 decision nodes regarding, 164
 final prostheses, 221
 placed immediately after surgery, 165–167, 166f, 190f–191f, 190–193
 placed within 24 to 48 hours after surgery, 167–168, 168f, 193, 195–201, 196f–201f
 single-tooth replacement
 in extraction sites, 175f–180f, 175–180
 in healed sites, 181–183, 182f
Edentulous arch
 buccolingual axis in, 55, 55f
 practitioner time necessary for treating, 4
 provisional options for, 1, 3f
Edentulous mandible
 abutments in, 121f, 122, 125, 125f
 alveolar ridge evaluations, 117, 118f
 anterior. *See* Edentulous anterior mandible.
 clinical conditions, 107, 108f
 complete dentition replacement
 in extraction sites, 122–126
 in healed sites, 117–122
 conversion prosthesis technique for, 109, 109f–110f
 delayed-loading protocol for, 19f
 esthetic considerations, 54
 from extractions, 108f
 final prosthesis for, 110
 flap elevation for, 126f, 126–127
 immediate loading in
 contraindications for, 116
 in extraction sites, 122–126
 in healed sites, 117–122
 indications for, 116
 prosthetic considerations, 117
 protocol for, 19f
 surgical considerations, 116–117
 implant failure in, 158
 implant placement
 distal to mental foramen, 153, 154f–155f
 in extraction sites, 124, 125f
 in healed sites, 118–122
 posterior. *See* Edentulous posterior mandible and maxilla.
 restoration of, 25–26

screw-retained final prosthesis, 114–116, 146–158, 147f–148f, 150f–155f
 screw-retained provisional prosthesis
 placed immediately after surgery, 113f, 113–114, 138–145, 140f, 142f–145f, 156–159
 placed within 24 hours after surgery, 111–113, 112f, 127–134, 129f, 131f–138f, 135–137, 156–159
 smile line evaluations, 117, 118f
 treatment of
 complications secondary to, 155–157
 control visits after, 153–155
 decision tree for, 109–111, 110f–111f
 types of, 108f
Edentulous maxilla
 abutments in
 description of, 78f
 esthetic considerations, 273, 274f
 final prosthesis on, 273, 274f
 healing, 256, 256f, 265, 267f
 transgingival, 236, 238, 250, 252f
 acrylic resin teeth fractures, 270
 anterior. *See* Edentulous anterior maxilla.
 buccolingual axis in, 55, 55f
 causes of, 224f
 cemented provisional prosthesis
 complications associated with, 270–271
 decision nodes for, 225
 final prosthetic phase, 272–273, 274f
 placed within 72 hours after surgery, 231–233, 232f, 253–266, 253f–266f
 clinical conditions, 224f
 complete dentition replacement
 in extraction sites, 236–238
 in healed sites, 234–236
 complications associated with, 268–271
 control visits for, 266, 268
 extractions, 223, 224f, 236–238
 healed sites in, 234–236
 immediate loading in
 description of, 223
 guidelines for, 233–238
 NanoTite surface application, 348–351
 implant failure in, 271, 272f
 implant placement
 in extraction sites, 237–238
 in healed sites, 235–236
 posterior. *See* Edentulous posterior mandible and maxilla.
 primary stability inadequacies in, 268
 screw-retained acrylic resin prosthesis with metal framework for, 245, 246f
 screw-retained provisional prosthesis
 complications associated with, 269f, 269–271
 decision nodes for, 225
 final prosthetic phase, 272–273, 274f

placed within 24 hours after surgery, 228–231, 229f, 247–252, 248f–252f
 placed within 48 to 72 hours after surgery, 227f, 227–228, 239f–246f, 239–246
 treatment options for, 224–274
Edentulous posterior mandible and maxilla
 case reports, 314–320
 cemented provisional prostheses
 decision nodes for, 306
 placed immediately after surgery, 310–311, 329–333, 330f–333f
 placed with 24 to 48 hours after surgery, 312–313, 333–337, 337f–338f
 clinical conditions associated with, 303, 304f
 complications associated with, 338–339
 control visits for, 338
 extraction sites, 316–320, 319f
 final prosthetic phase, 340
 healed sites, 314–320, 315f, 317f
 immediate loading in
 guidelines for, 313–320
 overview of, 303–304
 implant failure, 340
 implant placement
 in extraction sites, 318, 319f
 in healed sites, 315–316
 overview of, 303–304
 screw-retained provisional prostheses
 decision nodes for, 305–306
 placed immediately after surgery, 307–308, 320–324, 322f–324f
 placed within 24 to 48 hours after surgery, 308–310, 324–329, 325f, 327f–329f
 treatment options for, 304–340
Epithelial migration, 47, 50f
Esthetics, 71–74
Excess cement, 270, 339
Extraction sites
 in edentulous anterior mandible, 283–286, 285f
 in edentulous anterior maxilla, 175f–180f, 175–180, 183, 185–189
 in edentulous mandible, 122–126
 in edentulous maxilla, 236–238
 in edentulous posterior mandible and maxilla, 316–320, 319f
 immediate loading benefits in, 60, 61f
 implant placement in, 60–68, 61, 62f, 122–126
 mandibular anterior, 62, 64f
 maxillary anterior
 description of, 63–64, 65f–66f
 multiple sites, 183, 185–189
 single-tooth replacement in, 175–179
 molar, 67–68, 68f
 premolar, 64, 67f

F

Failure
 causes of, 95–96
 clinical signs of, 96–97
 in edentulous anterior mandible, 301

- in edentulous anterior maxilla, 220–221
- in edentulous mandible, 158
- in edentulous maxilla, 271, 272f
- in edentulous posterior mandible and maxilla, 340
- management of, 97–98
- multiple implants, 271

Fixed partial denture
anterior, 41

- in edentulous anterior maxilla, 162f
- implant-supported, 37, 38f
- posterior, 41
- short-span, 161

Flap elevation, for extraction sites in edentulous mandible, 126f, 126–127

Force

- at bone-implant interface, 36–42
- on implants, 14
- management of, 37–40

G

Gingiva

- landmarks of, 175, 176f
- recession of, 71, 78f

Gingival margin, 193, 195f

H

Hard tissues

- esthetics of, 72–74
- platform switching effects on, 77, 79f

Healed sites

- in edentulous anterior mandible, 286–287, 288f
- in edentulous anterior maxilla, 181–183, 182f
- in edentulous mandible, 118–122
- in edentulous maxilla, 234–236
- in edentulous posterior mandible and maxilla, 314–320, 315f, 317f

Healing

- bone. *See* Bone healing.
- immediate loading, benefits for, 21

Healing abutments, 178, 179f, 210, 211f, 236, 238, 256, 256f, 284, 285f, 296

Healing caps, 189, 193, 210, 250, 252f

Horizontal bone resorption, 52f

I

Immediate loading

- benefits of, 1–5, 2f–5f, 60
- costs specific to, 103–104
- delayed loading vs, 17
- dental technician's responsibilities in, 20
- edentulous anterior mandible. *See* Edentulous anterior mandible.
- edentulous anterior maxilla. *See* Edentulous anterior maxilla.
- edentulous mandible. *See* Edentulous mandible.
- edentulous maxilla. *See* Edentulous maxilla.
- edentulous posterior mandible and maxilla. *See* Edentulous posterior mandible and maxilla.
- emergence of, 9–10
- failure in first 6 weeks of, 98
- histologic findings, 11f
- of maxillary anterior segment, 22f

motivations for, 21, 23

NanoTite surface application, 348–351

occlusal, 41

principles of, 10–14

prosthodontist's responsibilities in, 20

protocols for, 2f, 8, 9b

for single-crown replacement in anterior maxilla, 26–27

team coordination for, 101

Immediate occlusal loading abutments, 121f, 122, 131, 133f

Implant(s)

- buccal angulation of, 219–220, 269, 269f, 300, 339

- distance between, 49, 51f–52f, 57, 61, 74, 74f

- distribution of, 36

- divergence of, 269

- in edentulous anterior mandible. *See* Edentulous anterior mandible.

- in edentulous anterior maxilla. *See* Edentulous anterior maxilla.

- in edentulous mandible. *See* Edentulous mandible.

- in edentulous maxilla. *See* Edentulous maxilla.

- in edentulous posterior mandible and maxilla. *See* Edentulous posterior mandible and maxilla.

- metallic reinforcement of, 39, 40f

- mobility of, 95–98, 97f

- number of, 36, 77, 102–103

- sites for, 46f

- vertical forces on, 14

Implant diameter

- failed implants replaced with larger-diameter implants, 97, 98f

- narrow, 57, 57f

- selection of, 61

- single-tooth replacement in edentulous anterior maxilla, 176, 177f

Implant neck

- abutment and, 75, 79f

- in alveolus, 177, 178f

- description of, 53, 53f

Implant placement

- circumstances for, 45, 46f

- coronoapical position, 53, 53f, 55–56, 56f

- mandibular anterior sites, 62, 64f

- mandibular premolar sites, 64, 67f

- maxillary anterior sites, 63–64, 65f–66f

- maxillary premolars sites, 64, 67f

- mesiodistal position, 54–55, 55f

- rules for, 45–53

- supracrestal, 56, 56f

- three-dimensional

- between adjacent structures, 74–75

- in extraction sites, 60–68, 124

- in healed sites, 54–60, 121, 122f

Implant protocols, 8, 8b

Implant splinting, 37, 39f

Implant stability, 98. *See also* Primary stability.

Implant stability quotient, 33–34

Implant surfaces

- bioactive, 343–351

- bone reaction affected by, 52f, 52–53

machined titanium, 52, 52f

micromovement and, 13f

NanoTite, 343–351

plasma-sprayed hydroxyapatite-coated, 12, 343

primary stability affected by, 34

roughened, 12, 52, 52f

Implant-abutment junction

- below osseous crest, 75

- at bone crest, 53, 74

- bone resorption at, 53, 74–75, 80–81

- buccal plate and, distance between, 75, 76f

- buccopalatal distance effects on, 76f

- insults at, 49f, 74, 81

- microgaps at, 47

Implant-alveolus gap, 62, 63f

Implant-tooth distance, 75

Impression fabrication, 211f

Impression transfer screw, 156

Infection, 80, 95

Insertion torque, 32, 32f

L

Laboratory, 21, 25

Loading

- delayed. *See* Delayed loading.

- failure caused by, 96

- immediate. *See* Immediate loading.

- micromovement and, 12, 13f

M

Machined titanium surface, 52, 52f

Mandible. *See* Edentulous anterior mandible; Edentulous mandible; Edentulous posterior mandible and maxilla.

Mandibular anterior teeth, 62, 64f

Mandibular molars, 67, 68f

Mandibular premolars, 64, 67f

Maxilla. *See* Edentulous anterior maxilla; Edentulous posterior mandible and maxilla.

Maxillary anterior segment

- esthetic management of soft tissues, 56, 56f

- immediate-loading protocol for, 22f

Maxillary anterior teeth

- implants for, 63–64, 65f–66f, 77

- labial axial inclination of, 63, 65f

Maxillary central incisor, 185f

Maxillary molars, 68

Maxillary premolars

- implant placement, 64, 67f

- rehabilitation of, 349f

- roots of, 64

Mechanical stress

- bone resorption caused by, 96

- bone responses to, 49, 52

- at bone-implant interface, 30f

- failure caused by, 96

- minimization of, 31f

- occlusion effects on, 40

Mesiodistal distance, 75

Mesiodistal position

- in esthetic zone, 57, 57f

- in extraction site, 61, 62f

- outside esthetic zone, 54–55, 55f

Micromovement

- biomechanical loading and, 12, 13f

- at bone-implant interface, 29, 30f

- description of, 10, 10t

implant surface and, 13f
at implant-abutment junction, 47
minimization of, 29
tolerance threshold to, 12f
Microstrain, 52
Mobile implants, 95–98, 97f

N

NanoTite, 343–351

O

Objective failure, 95
Occlusal contacts, 40, 41t
Occlusal surfaces, 41–42
Oral surgeon, 17
Osseointegration
 failure of, 96–97, 97f
 optimization of, 29–42
 protocols designed to promote, 9t
 radiographic verification of, 272
Osseous crest, 72, 75
Osseous envelope, 182f
Osseous remodeling, 11f
Osstell, 33f, 33–34, 266
Osteocytes, 96

P

Papillae, 87
Partially edentulous anterior maxilla, 2f–3f
Partially edentulous arch, 3f
Participants
 coordination between, 20–21
 description of, 17–20
Passive fit, 156, 219, 270, 300
Patient, 18
Patient fatigue, 219
Peri-implant tissue healing, 47–53
Peri-implantitis, 12
Periodontal biotypes
 abutment manipulation, 77, 78f
 cemented provisional prostheses
 for edentulous anterior maxilla
 affected by, 212, 214, 215f
 description of, 59, 59f
Periodontal ligament, 8
Periotest, 32–33, 33f, 266
Physical comfort, 23
Pictograms, 100–105
Plasma-sprayed hydroxyapatite
 coated implant surfaces, 12, 343
Platform switching
 definition of, 77
 description of, 75
 hard tissues affected by, 77, 79f
 Prevail implant, 82f–83f, 82–83
 theories on, 77, 80f–81f, 80–81
Posterior mandible and maxilla. *See*
 Edentulous posterior mandible
 and maxilla.
Postextraction sites
 implant placement in, 46f
 implant stability affected by, 35
Prevail implant, 82f–83f, 82–83
Primary stability
 bone effects on, 34–35
 description of, 34
 drilling sequence effects on, 35f–
 36f, 35–36
 in edentulous mandibles with heal-
 ed sites, 122
 importance of, 31

insertion torque measurements of,
 32, 32f
insufficient
 in edentulous anterior mandible,
 298, 300
 in edentulous anterior maxilla,
 218–219
 in edentulous mandible, 156, 157f
 in edentulous maxilla, 268
 in edentulous posterior mandible
 and maxilla, 338
 measurement of, 29–34
 optimizing of, 31f
 Osstell measurement of, 33f, 33–34
 Periotest measurement of, 32–33,
 33f
 of Prevail implant, 82
Prosthodontist, 17, 20–21
Provisional abutments, 85–87
Provisional prostheses
 acrylic resin teeth fractures in, 270
 fracture of, 270
 papillae presence during, 87
 screw-retained. *See* Screw-retained
 provisional prostheses.
Provisional restorations
 economic considerations, 23
 for edentulous arch, 1, 3f
Psychologic needs, 23, 105

R

Removable prostheses, 1, 3f
Risk assessment, 104
Rubber dam, 142, 143f

S

Screw-retained final prosthesis
 acrylic resin, with metal framework,
 243–245, 246f
 cemented provisional prosthesis
 and, 93, 93f
 screw-retained provisional pros-
 thesis and, 92, 92f
Screw-retained provisional pros-
theses
 cemented final prosthesis and, 92,
 93f
 description of, 89–90
 edentulous anterior maxilla. *See*
 Edentulous anterior maxilla.
 edentulous mandible. *See* Eden-
 tulous mandible.
 edentulous maxilla. *See* Eden-
 tulous maxilla.
 edentulous posterior mandible and
 maxilla. *See* Edentulous post-
 erior mandible and maxilla.
 screw-retained final prosthesis
 and, 92, 92f
Single-crown replacement
 in anterior maxilla, 26–27
 goals for, 60
 implant splinting for, 37, 39f
 occlusal contacts, 41
 rotational movements for, 37, 38f
Smile line, 117, 118f, 122, 123f, 176f,
 187f, 201f
Soft tissues, 47, 48f
Splinting of implant, 37, 39f
Subjective failure, 95
Submerged healing, 9, 9t, 97
Sulcus, 47, 48f

Surgeon, 18, 21
Surgical guide, 182f

T

Titanium abutments, 85f–86f, 205f,
 267f, 351, 351f
Titanium-aluminum-vanadium alloy,
 344, 347f
Tooth extraction, 4, 5f, 35. *See also*
 Extraction sites.
Transgingival abutments, 236, 238
Treatment determinants, 23–24, 105
Treatment planning, 99–105

Z

Zirconia abutment, 86f



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